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"EVERY MAN IS A VALUABLE MEMBER OF SOCIETY WHO, BY HIS OBSERVATIONS, RESEARCHES, AND EXPERIMENTS, PROCURES KNOWLEDGE FOR MEN"—JAMES SMITHSON

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LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

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VOLUME 128, NUMBER 1

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AMPHIPODA COLLECTED AT THE ARCTIC LABORATORY, OFFICE OF NAVAL RESEARCH, POINT BARROW, ALASKA, BY G. E. MacGINITIE[1]

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The material upon which this report is based was taken in the vicinity of Point Barrow, Alaska, at the United States Naval Research Station, from 1948 to 1951. Arctic species naturally predominate, but some North Atlantic and North Pacific species have intruded into the area, and one Antarctic genus, *Prothaumatelson,* is present. The range of several species has been extended northward, and of others, eastward or westward.

The collection contains 24 families, 64 genera, and 100 species of which 9 are new to science. There is also one new variety. The family Caprellidae is not included. The bulk of the collection is the result of the energetic work of Prof. George E. MacGinitie, while J. Bohlke and Dr. Ira L. Wiggins added valuable material in 1950 and 1951. All distances given as miles out are measured from the Point Barrow base.

In the literature cited under each species there is always a reference to a published figure if there is one. The length of a species is measured from the front of the head to the end of the uropods. The plan for the designation of the appendages is that used by T. R. R. Stebbing in Das Tierreich, I, Amphipoda: gnathopods 1 and 2, and peraeopods 1 to 5.

Suborder GAMMARIDEA

Family LYSIANASSIDAE

ANONYX NUGAX (Phipps)

Anonyx nugax Sars, 1891, p. 88, pl. 31.—Stephensen 1923, p. 78; 1944b, p. 26.
Anonyx nugax + *A. lagena* Stebbing, 1906, p. 54.

Material collected.—Many specimens of all sizes were taken from beach down to 522 feet, from 1948 to 1951.

[1] This paper has been published in part through a grant from the Office of Naval Research, through Johns Hopkins University.

Anonyx nugax is a circumpolar species that dips down into the North Atlantic and North Pacific. It has been taken off the coast of New England and off the coast of California.

The Point Barrow Expedition of 1881-1883 took considerable numbers of this species, which had been washed up on the beach in September 1882, but were identified as *Eurytenes gryllus* (Mandt). *Anonyx nugax* reaches a length of 45 mm. and has been taken as low as 1,184 m.

SOCARNES BIDENTICULATA (Bate)

Socarnes bidenticulatus Sars, 1885, pp.139, 276, pl. 12, fig. 1.—Stebbing, 1906, p. 56.—Stephensen, 1923, p. 87; 1944b, p. 28.

Material collected.—In 125 feet, September 9, 1948, 1 specimen. In 453 feet, 8 miles out, October 11, 1949, 1 specimen. In 175 feet, 4 miles out, October 14, 1949, 1 specimen. In 138 feet, 3.5 miles out, August 1, 1950, 1 specimen.

Socarnes bidenticulata is a circumpolar species. In the U. S. National Museum there are specimens taken off Newfoundland; Nakvak and Hebron, Labrador; Bering Sea; Aniwa Bay, Sakhalin Island; and Sea of Japan. It reaches a length of 36 mm., and Stephensen says that it is rarely found deeper than 100 m.

PSEUDALIBROTUS LITORALIS (Kröyer)

Alibrotus littoralis Sars, 1891, p. 102, pl. 35, fig. 2.
Pseudalibrotus litoralis Stebbing, 1906, p. 33.
Pseudalibrotus littoralis Stephensen, 1944b, p. 19.

Material collected.—Taken near the shore, July 1948 and 1949, 22 adults and 44 young. Washed ashore July 20, 1949, 6 specimens; July 26, 1949, 2 specimens; October 5, 1949, 1 specimen; and September 24 and 28, 1950, 2 specimens.

A mainly littoral species, distributed from Arctic America and Greenland to Nova Zembla; but replaced in the eastern part of the Arctic area (Kara Sea and Siberia) by a closely allied species, *P. birulai* Gurjanova. In the U. S. National Museum there are specimens from Nain, Labrador, and Kotzebue Sound, Alaska. Stebbing gives the length as 13 to 18 mm. According to published records, this species appears to range between the littoral and 200 m.

PSEUDALIBROTUS BIRULAI Gurjanova

Pseudalibrotus birulai Gurjanova, 1929a, p. 316, fig. 8; 1932, pp. 160, 181, pl. 2, figs. 1-8.

Material collected.—Taken in plankton tow 10 feet from shore, July 23 and 25, 1948, 2 specimens.

This species, which was described by E. Gurjanova from the Russian Arctic, measured about 11.5 mm. and was recorded from 6 and 22 m. The present records are the second of its occurrence.

ORCHOMENELLA MINUTA (Kröyer)

Orchomenella minuta Sars, 1890, p. 66, pl. 24, fig. 1; 1895, p. 683.—Stebbing, 1906, p. 82.—Stephensen, 1925, p. 123.

Material collected.—Taken near Elson Lagoon, August 3, 1948, 1 specimen. In 120 feet, September 15, 1948, 3 specimens. In 741 feet, 12.1 miles out, August 17, 1949, 1 specimen. In 150 feet, 3.5 miles out, October 14, 1949, 1 specimen. Taken in fish trap in 33 feet, 0.75 mile out, January 27, 1950, 1 specimen. In 135 feet, 3.1 miles out, March 9, 1950, 1 specimen. Taken in screen trap through hole in ice in 80 feet, 1.8 miles out, April 15, 1950, 5 specimens.

Orchomenella minuta is a circumpolar species which occurs down to about 160 m. It dips down into the North Atlantic to the southern coast of Norway and the coast of Maine. On the Alaskan coast it appears to be a common species and occurs south as far as Chignik Bay. It was taken by the Canadian Arctic Expedition, 1913-1918, at Bernard Harbor and Dolphin and Union Strait, Northwest Territories. This species reaches a length of 11 mm.

ORCHOMENELLA PINGUIS (Boeck)

Orchomenella pinguis Sars, 1890, p. 67, pl. 24, fig. 2; 1895, p. 683.—Stebbing, 1906, p. 82.—Stephensen, 1935, p. 107.

Material collected.—In 295 feet, 5 miles out, October 6, 1949, 2 specimens. In 152 feet, 3.5 miles out, October 14, 1949, 2 specimens. In 33 feet, 0.75 mile out, January 27, 1950, 1 specimen. In 80 feet, April 15, 1950, 30 specimens. In 64 feet, 1.25 miles out, May 17, 1950, 2 specimens (caught in fish trap through hole in ice).

Dr. Stephensen says that this species is probably circumpolar. It dips down on the Atlantic coast of America as far as Cape Hatteras, N. C. On the coast of Alaska it is an abundant species, and it occurs also at Kamchatka. It reaches a length of about 7 mm., and has been taken from shallow water down to about 565 m.

ORCHOMENELLA GROENLANDICA (Hansen)

Anonyx groenlandica Hansen, 1887a, p. 72, pl. 2, figs. 5-5g.
Orchomenella groenlandica Sars, 1891, p. 70, pl. 26, fig. 1; 1895, p. 648.—Stebbing, 1906, p. 83.—Shoemaker, 1920, p. 6.—Stephensen, 1925, p. 122; 1935, p. 109; 1944b, p. 38.

Material collected.—Off Point Barrow base in 120 feet, Septem-

ber 15, 1948, 1 specimen; and in 213 feet, 4 miles out, October 6, 1949, 1 specimen.

This species has been taken at East Greenland; Tromso, Norway, to White Sea; and Bernard Harbor, Northwest Territories. In the U. S. National Museum there are specimens from Bay of Fundy; off Newfoundland; Dobbin Bay, Ellesmere Land; and southern part of Fox Basin.

Orchomenella groenlandica measures about 7 mm., and Stephensen has recorded it off northern Norway between 40 and 100 m.

ARISTIAS TUMIDA (Kröyer)

Aristias tumidus Sars, 1890, p. 49, pl. 18, fig. 1.—Stebbing, 1906, p. 49.—Stephensen, 1923, p. 71; 1944b, p. 24.

Material collected.—In 125 feet, 4 to 5 miles out, September 9, 1948, 4 specimens, taken from the atrial cavity of ascidian, *Molgula retoviformis.* In 175 feet, 4 miles out, October 14, 1949, 2 specimens.

This species has been recorded from Siberian Polar Sea, Spitzbergen, North Norway, East and West Greenland, Newfoundland Bank, and now from Point Barrow.

Aristias tumida is occasionally found in the branchial chamber of ascidians. It reaches a length of 8 mm., and has been taken from the littoral down to 105 m.

ORCHOMENE SERRATA (Boeck)

Orchomene serratus Sars, 1890, p. 62, pl. 23, fig. 1; 1895, p. 682, pl. IV, fig. 1.—Stebbing, 1906, p. 44.—Stephensen, 1944b, p. 23.

Material collected.—Taken off Point Barrow base in 125 feet, September 9, 1948, 1 specimen.

This species has been recorded from Siberian Polar Sea, Spitzbergen, coast of Norway, Skagerrak, and east coast of Greenland. The present record is the first for Alaska. Stebbing gives the length as, ♀ 10 mm., ♂ about 6 mm. It has been taken down to about 660 m.

PARATRYPHOSITES ABYSSI (Goës)

Lysianassa abyssi Goës, 1866, p. 519, pl. 37, fig. 5.
Paratryphosites abyssi Stebbing, 1906, p. 43.—Shoemaker, 1930a, p. 18, fig. 10. —Gurjanova, 1938, pp. 245, 383.
Hippomedon abyssi Stephensen, 1913, p. 111.
Hippomedon stephenseni Frost, 1936, p. 7, fig.

Material collected.—In 741 feet, 12.1 miles out, August 17, 1949, 1 specimen.

This species has been recorded from West Greenland; east of Nova Scotia; off Newfoundland (*Hippomedon stephenseni* Frost); off Labrador; Sea of Japan; and now from Point Barrow, Alaska.

There are in the U. S. National Museum specimens from Cape Mugford and Port Manvers, Labrador; Cape Cod, Mass.; off Newport, R. I.; Nash Harbor, Nunivak Island, Alaska; and Cockburn Point, Arctic Canada. One specimen was taken by the *Albatross* at station 2314 (32° 43′ 00″ N., 77° 51′ 00″ W.) in 159 fathoms, constituting the most southern record for this species, which has been considered a northern and arctic form. *Paratryphosites abyssi* reaches a length of 17 mm., and occurs from shallow water down to 528 m.

ONISIMUS AFFINIS Hansen

Onisimus affinis HANSEN, 1887b, p. 216, pl. 21, fig. 9.—STEBBING, 1906, p. 28.—STEPHENSEN, 1923, p. 47; 1944b, p. 18.
Onisimus botkini SHOEMAKER, 1920, p. 4, figs. 1, 2.

Material collected.—In 438 feet, 12.1 miles out, August 17, 1949, 2 specimens. Washed ashore August 21, 1949, 1 specimen; September 19, 1949, 2 specimens; September 26, 1949, 2 specimens. Near shore in 7 feet, February 7, 1950, 1 specimen. Washed ashore September 24, 1950, 1 specimen; and September 28, 1950, 4 specimens.

This species has been recorded from New Siberian Islands; Kara Sea; Jan Mayen; East Greenland; King William Land, Arctic Canada; Collinson Point, Alaska; and now from Point Barrow, Alaska.

In the Report of the Canadian Arctic Expedition, 1913-18, this species was identified as *Onisimus botkini,* but Stephensen believes that Birula's species is a synonym of *Onisimus affinis* Hansen. It reaches a length of about 16 mm., and Stephensen says that the species is probably a circumpolar arctic littoral one (0 to 40 m.), which occasionally may be found in greater depths (162 to 207 m.).

ONISIMUS NORMANI Sars

Onisimus normani SARS, 1891, p. 106, pl. 36, fig. 2; 1895, p. 686.—STEBBING, 1906, p. 26.—STEPHENSEN, 1935, p. 38.

Material collected.—Taken off Point Barrow radio mast in 60 feet, September 8, 1948, 1 specimen.

This species has been recorded from the Siberian Polar Sea; North and South Norway; Cape Sable, Nova Scotia; Cabot Strait, Gulf of St. Lawrence; West Greenland; and now from Point Barrow, Alaska. It reaches a length of 9 mm. and has been taken down to 791 m. off West Greenland.

PARONESIMUS BARENTSI Stebbing

Figures 1, *a-g*, and 2, *a-m*

Paronesimus barentsi STEBBING, 1894, p. 14, pl. 2; 1906, p. 43.—STEPHENSEN, 1935, p. 51, fig. 5.—GURJANOVA, 1936a, pp. 34 and 44.

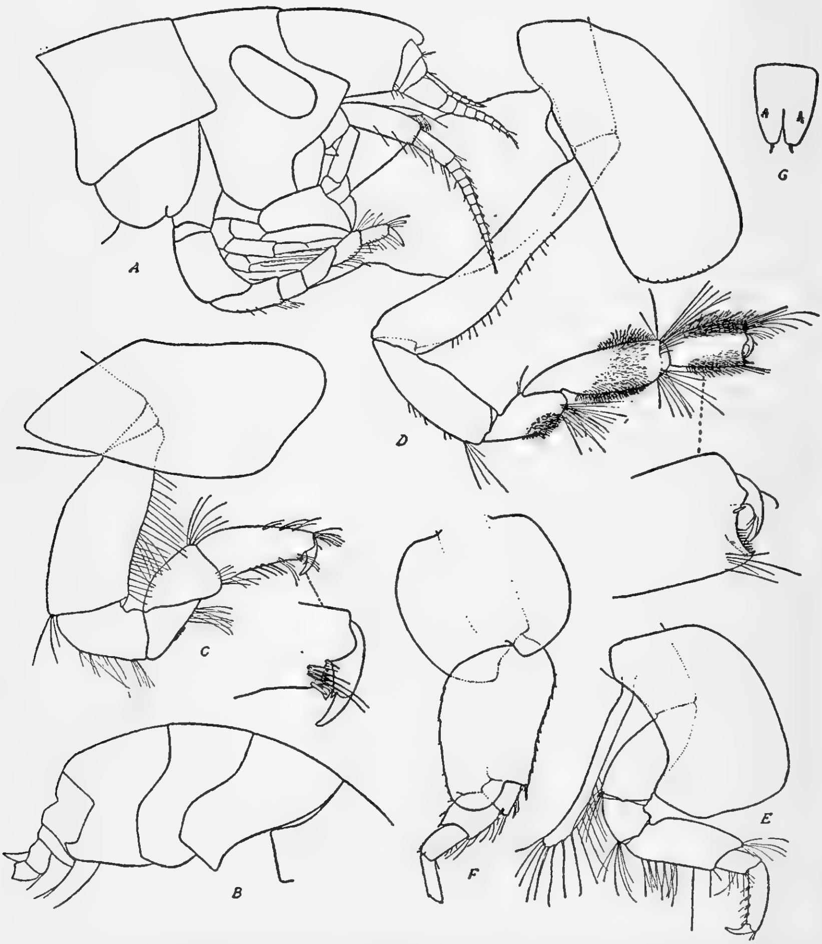

FIG. 1.—*Paronesimus barentsi* Stebbing. Female: *a*, front of animal; *b*, hind end of animal; *c*, gnathopod 1; *d*, gnathopod 2; *e*, peraeopod 2; *f*, peraeopod 3; *g*, telson.

Material collected.—Washed ashore, October 5, 1949, 1 specimen. In 152 feet, 3.5 miles out, October 14, 1949, 1 specimen. Near Point Barrow, 300 yards offshore, July 29, 1951, 1 specimen.

This species was described from Barents Sea in 1894, and has since been recorded from west of Nova Zembla and Kara Sea, and Stephen-

sen says that it is not known outside of this area. The present specimens from Point Barrow, therefore, extend the range of this species halfway around the polar regions. The length of the female here figured is about 14 mm. Stebbing gives 125 m. as the depth for this species.

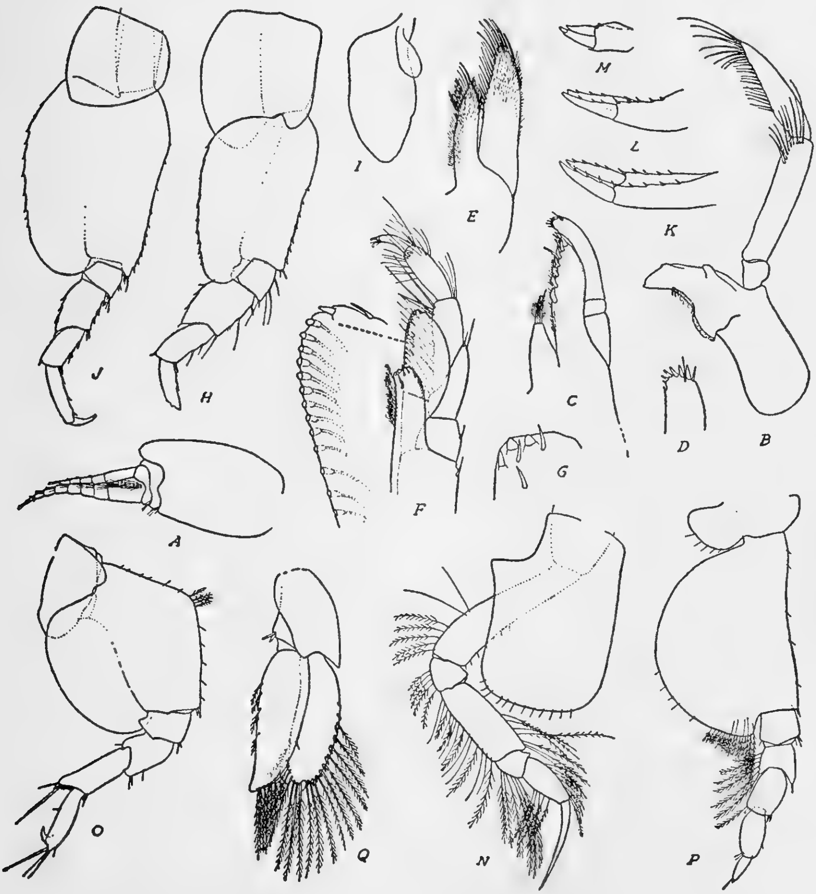

FIG. 2.—*a-m, Paronesimus barentsi* Stebbing. Female: *a*, right antenna 1, inside view; *b*, right mandible, inside view; *c*, maxilla 1; *d*, end of palp, maxilla 1; *e*, maxilla 2; *f*, right maxilliped; *g*, end of inner plate, right maxilliped; *h*, peraeopod 4; *i*, gill of peraeopod 4; *j*, peraeopod 5; *k*, uropod 1; *l*, uropod 2; *m*, uropod 3. *n-q, Ampelisca birulai* Brüggen. Female: *n*, peraeopod 2; *o*, peraeopod 4; *p*, peraeopod 5; *q*, uropod 3.

TRYPHOSA TRIANGULA Stephensen

Tryphosa triangula STEPHENSEN, 1925, p. 104, fig. 24; 1940b, p. 13.—GURJANOVA, 1936b, p. 246.

Material collected.—Taken from fish trap off Point Barrow base, in 33 feet, 0.75 mile out, January 27, 1950, 1 specimen ♀.

Tryphosa triangula was described from 4 males measuring 7 mm., taken southwest of Iceland (63° 15′ N., 22° 23′ W., 216 to 326 m.). Gurjanova, in 1936, recorded 8 specimens from the Kara Sea. The present specimen from Point Barrow, a female, measuring about 10 mm., makes the third record of the occurrence of this species.

TRYPHOSA GROENLANDICA Schellenberg

Tryphosa groenlandica SCHELLENBERG, 1935, p. 20.—STEPHENSEN, 1944b, p. 33, fig. 1.

Material collected.—Taken in 37 feet, March 10, 1950, 2 specimens (caught in screen trap through hole in ice).

This species was described by A. Schellenberg from East Greenland in 1935, and Stephensen recorded it from East Greenland in 1944. The two specimens taken at Point Barrow agree in all details with the original description, and show plainly the unusually long peduncle of the second uropod, as figured by Stephensen. The present record is the first for the occurrence of this species outside of East Greenland. *Tryphosa groenlandica* reaches a length of 10 mm., and it has been taken down to 12 m.

Family STEGOCEPHALIDAE

STEGOCEPHALOPSIS AMPULLA (Phipps)

Stegocephalus ampulla MURDOCH, 1885b, p. 145.—BRÜGGEN, 1909, p. 14, pl. 1, fig. 1; pl. 3, figs. 11-19.
Phippsia ampulla STEBBING, 1906, p. 89.
Stegocephalopsis ampulla SCHELLENBERG, 1924, p. 200.—STEPHENSEN, 1935, p. 112, fig. 18; 1944b, p. 39.

Material collected.—Taken in 125 feet, 4 to 5 miles out, September 9, 1948, 1 specimen.

A large species, probably circumpolar. It was recorded by Murdoch from Point Barrow in 1885, from specimens taken by the Point Barrow Expedition of 1881-1883. In the U. S. National Museum there are specimens from Hare Island, West Greenland; Indian Point, Bering Strait; and a specimen, measuring 56 mm., taken by the steamer *Albatross* at station 5018 in Okhotsk Sea. It has been taken between 165 and 672 m.

STEGOCEPHALUS INFLATUS Kröyer

Stegocephalus inflatus SARS, 1891, p. 198, pl. 69.—STEBBING, 1906, p. 91.—SHOEMAKER, 1920, p. 9; 1930b, p. 244.—STEPHENSEN, 1925, p. 129; 1944b, p. 39.—GURJANOVA, 1935a, p. 72.

Material collected.—Taken in 130 feet, 4 miles out, August 9,

1949, 1 specimen; and in 138 feet, 3.5 miles out, August 1, 1950, 1 specimen. At Point Barrow base, summer 1951, 3 specimens, and June 4-5, 1951, 5 specimens.

This is a rather common Arctic and North Atlantic species. In the U. S. National Museum there are specimens from the east coast of America from Frobisher Bay, Baffin Land, to Marthas Vineyard; and on the west coast from Alaska. It has been recorded from Plover Bay, East Siberia; Bering Sea; off Cape Clonard, Korea; Sakhalin Island; and Sado Island, Sea of Japan. Large specimens reach a length of 47 mm. It has been taken down to 640 m.

Family AMPELISCIDAE

AMPELISCA MACROCEPHALA Lilljeborg

Ampelisca macrocephala Sars, 1890, p. 172, pl. 60, fig. 1.—Stebbing, 1906, p. 101.—Stephensen, 1935, p. 123; 1944b, p. 48.

Material collected.—In 162 feet, 3.2 miles out, February 18, 1950, 1 specimen.

Dr. Stephensen says that this is a widely distributed circumpolar species, and occurs in the Atlantic at Jamaica Bay, Long Island, N. Y.; southern Greenland; northern Iceland; and the Danish waters.

In the U. S. National Museum there are specimens of this species from the Bay of Fundy and Delaware on the east coast of America, and off San Diego, Calif., on the west coast. K. H. Barnard (1932, p. 82) has recorded specimens from South Georgia which he says are extraordinarily close to *macrocephala* Lillj., and which he has identified as that species. Dr. A. Schellenberg has described two forms of *A. macrocephala* from the South Pacific (1931, pp. 52 and 53).

The present specimen from Point Barrow is a male measuring 26 mm. This species has been recorded between 350 and 400 m.

AMPELISCA ESCHRICHTII Kröyer

Ampelisca eschrichtii Sars, 1891, p. 174, pl. 61, fig. 1.—Stebbing, 1906, pp. 100, 721.—Stephensen, 1935, p. 121; 1944b, p. 47.

Material collected.—In 100 feet, August 21, 1948, 1 specimen. Washed ashore at Point Barrow base, October 16, 1949, 1 specimen. Taken under ice along shore ¼ mile south of base, November 20, 1949, 1 specimen.

Dr. Stephensen says that this is a widely distributed circumpolar species; also in the Atlantic with adjacent waters north of a line from northern United States, southern Greenland, southern Iceland and Faroe Channel to West Norway; and two hauls south and east of Ireland.

In the U. S. National Museum there are specimens from Big Diomede Island; Punuk Island, Bering Sea; and Parlof Bay, Alaska. Dr. Charles Chilton (1917, p. 75) says that *A. eschrichtii* is widely distributed in Antarctic seas. He believed that *A. macrocephala* Lilljeborg should be united with this species. *A. eschrichtii* reaches a length of 34 mm., and has been taken as low as 400 m.

AMPELISCA BIRULAI Brüggen

Figures 2, *n-q*, 3, *a-c*

Ampelisca birulai Brüggen, 1909, p. 17, pl. 1, fig. 5, pl. 3, figs. 1-10.
Ampelisca derjugini Bulycheva, 1936, p. 244, figs. 4-6.

Material collected.—In 80 feet, September 9, 1948, 1 specimen. In 216 feet, 4.3 miles out, October 6, 1949, 1 specimen. In 175 feet, 4 miles out, October 14, 1949, 2 specimens. In 162 feet, 3.2 miles out, February 18, 1950, 2 specimens. In 118 feet, 2.75 miles out, August 1, 1950, 1 specimen. Dredged at 6 to 50 m., July 29, 1951, 1 specimen.

This is the third record of the occurrence of this species, which was described by Ernst von der Brüggen (77° 20′ 30″ N., 138° 47′ E.) from 80 m. in the Arctic Ocean. The present records extend the range about 67° eastward. Eight specimens were taken off Point Barrow, the largest of which, a female, measures about 10 mm.

Ampelisca derjugini, measuring 16 to 18 mm., described by A. Bulycheva from the northern part of the Sea of Japan, appears to be a synonym of *A. birulai* Brüggen.

HAPLOOPS TUBICOLA Lilljeborg

Haploops tubicola Sars, 1891, p. 192, pl. 67.—Stebbing, 1906, p. 117.—Stephensen, 1925, p. 150; 1933, p. 25; 1935, p. 135; 1944b, p. 49.

Material collected.—On the beach at Point Barrow base, September 24, 1950, 1 specimen. On the beach at Point Barrow base, September 28, 1950, 3 specimens.

Dr. Stephensen says that this is a circumpolar, boreoarctic species. It dips down into the Atlantic to the Bay of Fundy and West Morocco. In the Pacific it has been recorded from Japan by Derjavin (1930, p. 327). The largest specimen in the present collection, a male, measures 19 mm. It has been taken off East Greenland between 400 and 600 m.

HAPLOOPS LAEVIS Hoek

Haploops laevis Hoek, 1882, p. 61, pl. 3, fig. 31.—Stebbing, 1906, p. 117.—Stephensen, 1935, p. 137, fig. 19.—Gurjanova, 1935a, p. 73.

Material collected.—In 741 feet, 12.1 miles out, August 17, 1949,

2 specimens. In 477 feet, 16 miles out, September 6, 1949, 1 specimen. In 246 feet, 7 miles out, September 8, 1949, 1 specimen. In 213 feet, 4 miles out, October 6, 1949, 7 specimens. In 453 feet, 8 miles out, October 11, 1949, 1 specimen. In 175 feet, 4 miles out, October 14,

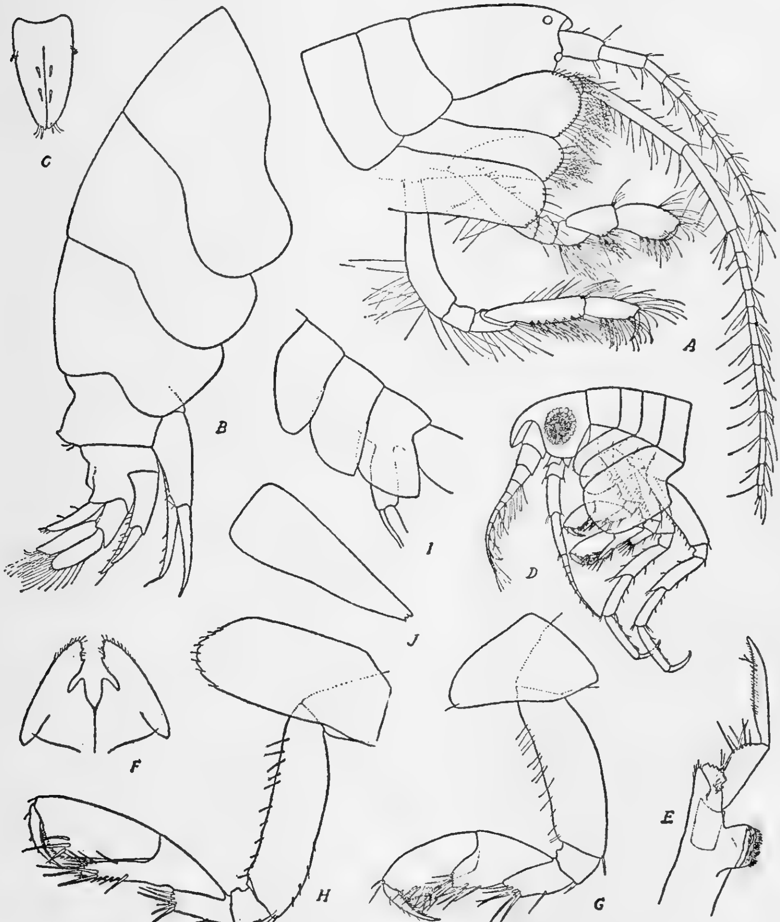

FIG. 3.—*a-c*, *Ampelisca birulai* Brüggen. Female: *a*, front of animal; *b*, hind end of animal; *c*, telson, *d-j*, *Gitanopsis arctica* Sars. Male: *d*, front end of animal; *e*, mandible, showing side view of palp; *f*, lower lip; *g*, gnathopod 1; *h*, gnathopod 2; *i*, metasome; *j*, telson.

1949, 5 specimens. In 152 feet, 3.5 miles out, October 14, 1949, 5 specimens. In 129 feet, 2.5 miles out, February 13, 1950, 1 specimen. In 162 feet, 3.2 miles out, February 18, 1950, 12 specimens. Dredged in 45 m., July 24, 1951, 1 specimen. Dredged at 6 to 50 m., July 29, 1951, 3 specimens.

Haploops laevis is widely distributed in the Arctic and is probably circumpolar. The present records are the first for Alaska. It reaches a length of 19 mm. and has been taken between 360 and 380 m.

BYBLIS GAIMARDII (Kröyer)

Byblis gaimardi SARS, 1891, p. 183, pl. 64.—STEPHENSEN, 1935, p. 132; 1944b, p. 48.
Byblis gaimardii STEBBING, 1906, p. 113.

Material collected.—In 150 feet, August 23, 1948, 1 specimen. In 80 feet, September 9, 1948, 22 specimens. In 420 feet, August 9, 1949, 1 specimen. In 217 feet, 7.5 miles out, September 6, 1949, 1 specimen. In 246 feet, 7 miles out, September 8, 1949, 5 specimens. In 213 feet, 4 miles out, October 6, 1949, 14 specimens. In 216 feet, 4.3 miles out, October 6, 1949, 2 specimens. In 162 feet, 3.2 miles out, February 18, 1950, 1 specimen. In 1,170 feet, April 11, 1950, 1 specimen. Off Point Barrow, July 27, 1950, 12 specimens. In 138 feet, 3.5 miles out, August 1, 1950, 40 specimens. Dredged in 6 to 5 m., July 29, 1951, about 100 specimens.

Dr. Stephensen says that this species is widely distributed in the northern Atlantic north of a line from the Bay of Fundy and West Greenland about 64° N. to South Iceland and British and Danish waters. It is probably circumpolar. S. J. Holmes recorded it from Monterey Bay, Calif. E. Gurjanova recorded it from the Sea of Japan in 1938. There are specimens in the U. S. National Museum from Vineyard Sound off Marthas Vineyard. The present records are the first for Alaska. This species reaches a length of 23 mm. The lowest recorded depth appears to be 475 to 575 m. (Norman, 1895, p. 484).

Family HAUSTORIIDAE

PONTOPOREIA FEMORATA Kröyer

Pontoporeia femorata SARS, 1891, p. 123, pl. 41, fig. 1, ♀.—STEBBING, 1906, p. 128.—STEPHENSEN, 1925, p. 157; 1938, p. 144; 1944b, p. 50.—SEGERSTRÅLE, 1937, p. 168.
Pontoporeia sinuata EKMAN, 1913, p. 3, figs. 1-8, ♂.
Pontoporeia ekmani BULYCHEVA, 1936, p. 246, figs. 7-11, ♀.

Material collected.—In 741 feet, 12.1 miles out, August 17, 1949, 18 specimens. In 477 feet, 16 miles out, September 6, 1949, 2 specimens. Washed ashore September 19, 1950, 2 specimens; September 26, 1949, 29 specimens; and September 24, 1950, 61 specimens.

Pontoporeia femorata is a circumpolar species which dips down into the cold waters of the North Atlantic and North Pacific. In the

U. S. National Museum there are specimens from *Albatross* Station 2497 (45° 04′ N., 59° 36′ W.); Casco Bay, Maine; and Salem, Mass.

Sven G. Segerstråle (1937, pp. 1-183) has given a revision of *Pontoporeia* and has concluded that *P. sinuata* Ekman is the male of *P. femorata* Kröyer. *Pontoporeia ekmani* Bulycheva (1936, p. 246), described from the Sea of Japan, appears to be a synonym of *P. femorata*. His figures 7-11 show the characters of the female of *P. femorata,* some of the specific characters of which are quite variable. Bulycheva's description and figures of the dorsal protuberance of the first urosome segment agree with those given by Ekman for *P. sinuata,* which Segerstråle believes is a synonym of *P. femorata.*

Both male and female specimens were taken in 471 feet of water off Point Barrow. The characters of the male agree well with those given by Ekman for *P. sinuata. Pontoporeia femorata* reaches a length of 17 mm., and occurs as low as 188 m.

Family AMPHILOCHIDAE

GITANOPSIS ARCTICA Sars

Figures 3, *d-j,* 4, *a-j*

Gitanopsis arctica Sars, 1892, p. 227, pl. 77, fig. 2.—Stebbing, 1906, p. 155.—Stephensen, 1938, p. 161; 1940b, p. 28.

Material collected.—In 125 feet, 4 to 5 miles out, September 9, 1948, 1 specimen. In 216 feet, 4⅓ miles out, October 6, 1949, 1 specimen. In 175 feet, 4 miles out, October 14, 1949, 1 specimen.

Gitanopsis arctica has been recorded from south of Nova Zembla, North Norway, Iceland, and South Greenland. In the United States National Museum there are specimens from Northumberland Island, Murchison Sound, North Greenland; and the Bay of Fundy. The present records from Alaska extend the range of this species considerably westward. This is a small species reaching a length of 5 mm. It has been recorded from shallow water down to 90 m.

Family STENOTHOIDAE

In the Stenothoidae several of the characters are apparently undergoing a change. The accessory flagellum may be retained as a rudimentary 1-jointed appendage, but is usually missing. The palp of the mandible may be reduced to two joints or one, or may be entirely missing. In maxilla 1 the palp may be reduced to one joint. The second joint of the last two peraeopods may be expanded, or reduced to the linear state in one or both of these appendages. In

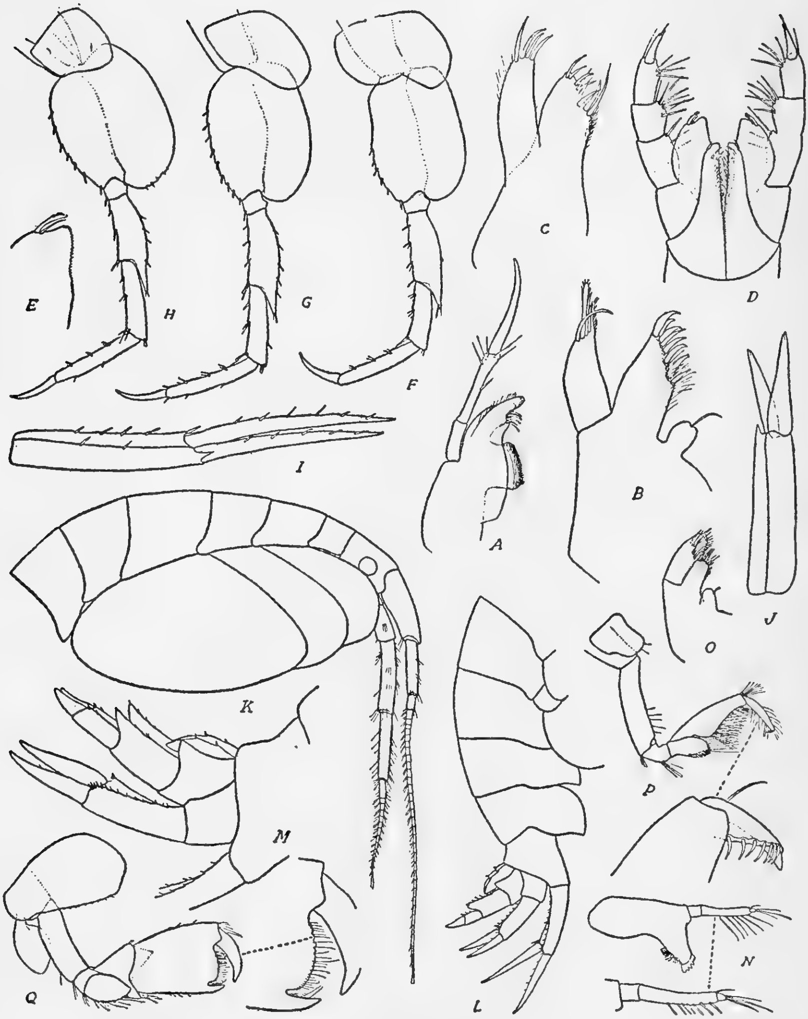

FIG. 4.—*a-j, Gitanopsis arctica* Sars. Male: *a,* mandible, giving side view of palp; *b,* maxilla 1; *c,* maxilla 2; *d,* maxillipeds; *e,* end of inner plate of maxilliped, greatly enlarged; *f,* peraeopod 3; *g,* peraeopod 4; *h,* peraeopod 5; *i,* uropod 1; *j,* uropod 3. *k-q, Metopa clypeata* (Kröyer). Male: *k,* front end of animal; *l,* hind end of animal; *m,* uropods 2 and 3 and telson of another male; *n,* mandible; *o,* maxilla 1; *p,* gnathopod 1; *q,* gnathopod 2.

the third uropod one of the rami has been lost. The first coxal plate has been lost. The fourth coxal plate in most cases is moderately expanded, but may become so greatly expanded that all of the body appendages are covered when the animal is flexed.

Eupraxie Gurjanova (1938, p. 261) constructed a key to the genera of the Stenothoidae based upon the variation in these appendages. The present key is based upon that of Gurjanova with the characters arranged in a somewhat different order.

KEY TO THE GENERA OF THE STENOTHOIDAE

A. Peraeopods 4 and 5, second joint linear.
  1. Maxilla 1, palp 1-jointed.
    Mandibular palp absent..............*Parametopella* Gurjanova 1938
    Mandibular palp 1-jointed............*Metopelloides* Gurjanova 1938
    Mandibular palp 2- or 3-jointed................*Metopella* Sars 1892
  2. Maxilla 1, palp 2-jointed.
    Mandibular palp 3-jointed..............*Probolisca* Gurjanova 1938
B. Peraeopod 4, second joint linear; peraeopod 5, second joint expanded.
  1. Maxilla 1, palp 1-jointed.
    Mandibular palp 1-jointed or absent
      Mesostenothoides Gurjanova 1938
    Mandibular palp 2-or 3-jointed........*Mesometopa* Gurjanova 1938
  2. Maxilla 1, palp 2-jointed.
    Mandibular palp 3-jointed..........*Mesoproboloides* Gurjanova 1938
C. Peraeopods 4 and 5, second joint expanded.
  1. Maxilla 1, palp 1-jointed.
    Mandibular palp absent.................*Parametopa* Chevreux 1901
    Mandibular palp 1-jointed ....*Stenothoides* Chevreux 1900
    Mandibular palp 2- or 3-jointed.
      Without accessory flagellum..................*Metopa* Boeck 1871
      With rudimentary 1-jointed flagellum *Prometopa* Schellenberg 1926
  2. Maxilla 1, palp 2-jointed.
    Mandibular palp absent.
      Without accessory flagellum................*Stenothoe* Dana 1852
      With rudimentary 1-jointed accessory flagellum
        Microstenothoe Pirlot 1933
    Mandibular palp 1-jointed............*Prostenothoe* Gurjanova 1938
    Mandibular palp 2- or 3-jointed.
      Without accessory flagellum.........*Proboloides* Della Valle 1893
      With rudimentary 1-jointed accessory flagellum
        Metopoides Della Valle 1893

METOPA CLYPEATA (Kröyer)

Figures 4, *k-q*, 5, *a-f*

Leucothoe clypeata Kröyer, 1842, p. 157; 1845, p. 545, pl. 6, fig. 2a-f.
Metopa clypeata Boeck, 1871, p. 140.—Hansen, 1887a, p. 90, pl. 3, figs. 3-3b.—Stebbing, 1906, p. 175.—Stephensen, 1913, p. 137; 1931, p. 183; 1933, p. 26; 1944b, p. 57.—Shoemaker, 1930b, p. 263.

Material collected.—Eluitkak Pass, Elson Lagoon, August 10, 1948, 15 specimens. In 125 feet, 4-5 miles out, September 9, 1948, 1 specimen. In 120 feet, 3 miles out, August 8, 1949, 4 specimens. In 184 feet, 5 miles out, August 30, 1949, 5 specimens. In 217 feet, 7.5 miles out, September 6, 1949, 5 specimens. In 477 feet, 16 miles out,

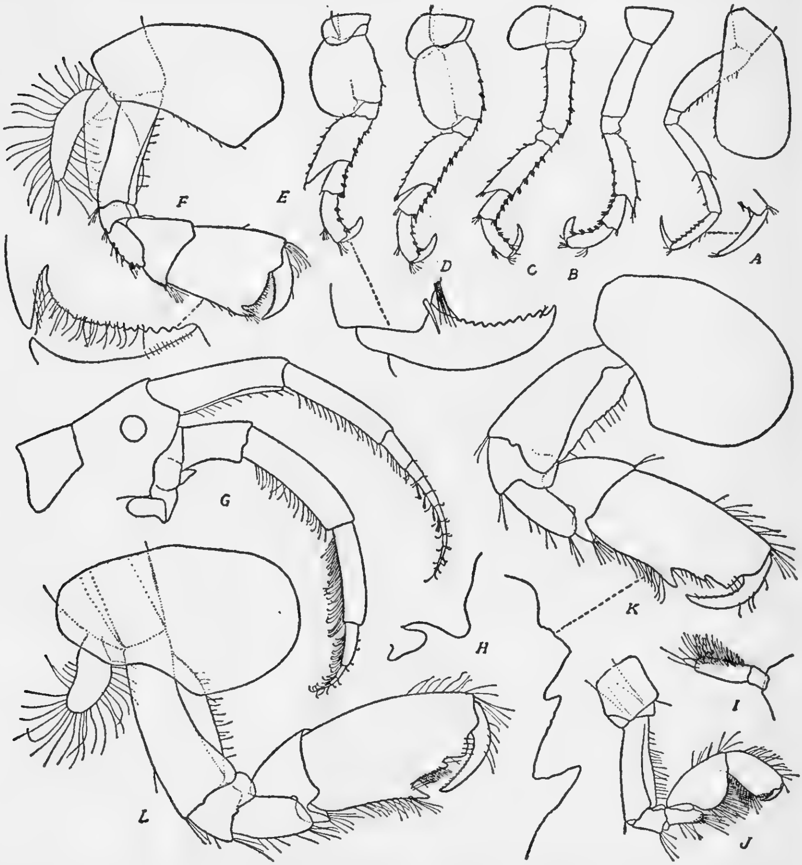

FIG. 5.—*a-f, Metopa clypeata* (Kröyer). Male: *a*, peraeopod 1; *b*, peraeopod 2; *c*, peraeopod 3; *d*, peraeopod 4; *e*, peraeopod 5. Female: *f*, gnathopod 2. *g-l, Metopa glacialis* (Kröyer). Male: *g*, front end of animal; *h*, upper lip and epistome; *i*, palp of mandible; *j*, gnathopod 1; *k*, gnathopod 2. Female: *l*, gnathopod 2.

September 6, 1949, 1 specimen. In 213 feet, 4 miles out, October 6, 1949, 4 specimens. In 216 feet, 4.3 miles out, October 6, 1949, 1 specimen. In 453 feet, 8 miles out, October 11, 1949, 3 specimens. In 152 feet, 3.5 miles out, October 14, 1949, 2 specimens. In 175 feet, 4 miles out, October 14, 1949, 9 specimens.

Male.—Figures of some of the appendages have been given here which will help in the identification of this species. The lateral lobes of the head are broadly rounding and the eye is of medium size and light in color in alcohol. Antenna 1 longer than antenna 2, both rather slender. Maxilla 1 with a 1-jointed palp. Mandible with a 3-jointed palp. Gnathopod 1 slender and much like that of *Metopa spitzbergensis* Brüggen. Gnathopod 2 strongly developed, the fourth joint with several groups of short spines on the lower margin; sixth joint widening distally, palm transverse with a deep indentation adjacent to the strong defining tooth; seventh joint strong and curved. Peraeopod 1 slender. Peraeopod 2 stouter than 1; seventh joint with a row of blunt teeth on inner margin. Peraeopods 4 and 5 with second joint greatly expanded. Peraeopod 4 with fourth joint much longer than wide. Peraeopod 5 with fourth joint considerably expanded but proportionally shorter than that of peraeopod 4. Uropod 3 with peduncle distally produced. Telson with 2 small spines on either lateral margin. *M. clypeata* is a large species measuring 14 mm.

Female.—The female is very much like the male. Gnathopod 2 is not quite so strongly built and the characters are not so pronounced, but it closely resembles that of the male. The largest females are as large as the fully developed males.

Metopa clypeata has been recorded from East and West Greenland and the Gulf of St. Lawrence, and has been taken as low as 300 m. The present records are the first for Alaska.

METOPA GLACIALIS (Kröyer)

Figures 5, *g-l*, 6, *a-d*

Leucothoe glacialis Kröyer, 1842, p. 159; 1846b, pl. 22, fig. 3a-p.
Stenothoe clypeata Stimpson, 1854, p. 51.
Metopa glacialis Hansen, 1887a, p. 93, pl. 3, figs. 6, 6a.—Stephensen, 1913, p. 139.
Proboloides glacialis Stebbing, 1906, p. 189.—Stephensen, 1931, p. 194; 1938, p. 178, fig. 21.
Metopa cariana Gurjanova, 1929a, p. 313, fig. 5.—Schellenberg, 1935, p. 23.—Stephensen, 1944b, p. 56.

Material collected.—In 477 feet, 16 miles out, September 6, 1949, 4 specimens.

Metopa glacialis (Kröyer), *Stenothoe clypeata* Stimpson, and *Metopa cariana* Gurjanova appear to be one and the same species. They are alike in form, occur at about the same depths, are of the same length, and inhabit the cold waters of the North Atlantic and Arctic Oceans. Schellenberg states that in *glacialis* the first maxilla

has a 2-jointed palp, which would place it in the genus *Proboloides.* Specimens of *clypeata* from the Bay of Fundy and *glacialis* from Point Barrow and Nunivak Island, Alaska, have been dissected and all have been found to have a 1-jointed palp to the first maxilla. The

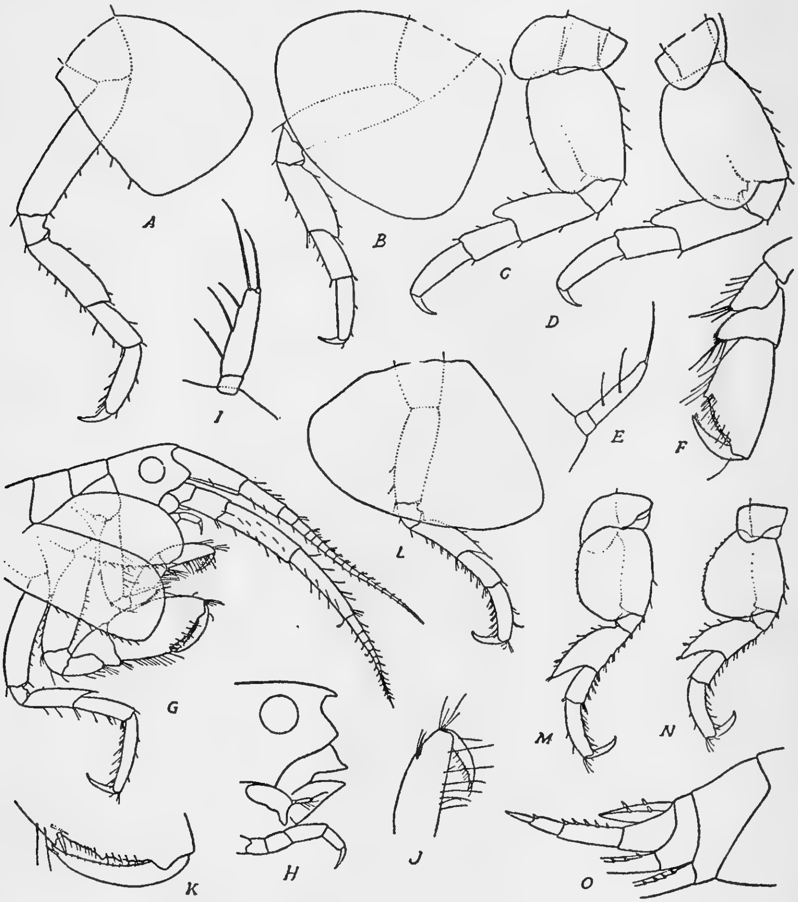

FIG. 6.—*a-d, Metopa glacialis* (Kröyer). Male: *a,* peraeopod 1; *b,* peraeopod 2; *c,* peraeopod 4; *d,* peraeopod 5. *e-f, Metopa bruzelii* (Goës). Female: *e,* palp of mandible; *f,* gnathopod 1. *g-o, Metopa spinicoxa,* new species. Male: *g,* front part of animal; *h,* head, showing upper lip and epistome; *i,* palp of mandible; *j,* end of gnathopod 1; *k,* palm and seventh joint, gnathopod 2; *l,* peraeopod 2; *m,* peraeopod 4; *n,* peraeopod 5; *o,* hind end of animal.

specimen of *Metopa cariana,* which Stephensen received from Gurjanova, was dissected and found to have a 1-jointed palp. In view of the extreme similarity of these three species, it seems possible that the number of joints in the palp of the first maxilla may be a variable

character, and that this palp is being reduced to a 1-jointed appendage. The mandible of *Metopa glacialis* has a 3-jointed palp, as shown in figure 5, *i*.

The specimens here figured measure about 7.5 mm. and were taken at Dodge Harbor, Nunivak Island, Alaska, by Woodbridge Williams. These specimens agree in every particular with specimens taken at Point Barrow, and all have a 1-jointed palp to the first maxilla. Specimens of *Stenothoe clypeata* Stimpson taken in the Bay of Fundy near Grand Manan agree with the specimens of *glacialis* taken at Point Barrow. In the Alaskan specimens the telson appears to be a little longer, reaching just beyond the end of the peduncle of uropod 3.

Metopa glacialis (Kröyer) has been recorded from Spitzbergen, White Sea, Iceland, and West Greenland.

Metopa clypeata (Stimpson) has been recorded from the Bay of Fundy.

Metopa cariana Gurjanova has been recorded from Nova Zembla and East Greenland.

The animals described under these three names appear to represent one and the same species and are being placed under the oldest name, *Metopa glacialis* (Kröyer). *Metopa clypeata* (Kröyer) is a distinct species and not at all like *Stenothoe clypeata* Stimpson. Stebbing (1906, Das Tierreich, p. 725) makes *Stenothoe clypeata* Stimpson a synonym of *Metopa groenlandica* (Hansen), but this is not correct, as the two species, though related, are distinct.

Stephensen and Thorson (1936, pp. 1-7) record *M. groenlandica* as being commensal in the mantle cavity of the lamellibranch, *Pandora glacialis* Leach, found on the east coast of Greenland. Ten specimens of *Metopa glacialis* have been found in the mantle cavity of a lamellibranch, *Mediolaria discors* Linn., dredged in about 3 fathoms in the St. Croix River, New Brunswick, near the Atlantic Biological Station.

There are in the United States National Museum specimens of *M. glacialis* taken at Dodge Harbor, Nunivak Island, Alaska, by Woodbridge Williams in the summer of 1937, and 5 specimens taken by Dr. Waldo L. Schmitt, October 8, 1940, between Inner Iliasik and Goloi Island, Alaska, while on the Alaska king crab investigation. The present records are the first for *Metopa glacialis* in Alaska. This species reaches a length of 7 to 8 mm., and has been recorded as low as 275 m.

METOPA BRUZELII (Goës)

Figure 6, *e-f*

Montagua bruzelii Goës, 1866, p. 522, pl. 38, fig. 10.
Metopa bruzelii Sars, 1892, p. 261, pl. 92, fig. 1.—Stephensen, 1931, p. 181; 1938, p. 169; 1944b, p. 56.
Proboloides bruzelii Stebbing, 1906, p. 188.—Shoemaker, 1930b, p. 270.

Material collected.—In 80 to 125 feet, September 8 to 15, 1948, 4 specimens. In 453 feet, 8 miles out, October 11, 1949, 11 specimens. In 175 feet, 4 miles out, October 14, 1949, 1 specimen.

Metopa bruzelii has been recorded from Spitzbergen, North Norway, Kattegat, Isle of Man, North Wales, Firth of Forth, Iceland, East and West Greenland, and Gulf of St. Lawrence. The present records are the first for Alaska. This is a small species measuring about 4 mm., and has been taken from 10 to 200 m.

As Stephensen has noted (1931, p. 182) the first maxilla of this species has a 1-jointed palp. The specimens from Point Barrow also have a 1-jointed palp and the mandible has a 2-jointed palp, which correctly place the species in the genus *Metopa.*

METOPA LONGICORNIS Boeck

Metopa longicornis Boeck, 1871, p. 143.—Sars, 1892, p. 258, pl. 90, fig. 2; 1900, p. 33.—Stebbing, 1906, p. 179.—Stephensen, 1931, p. 188; 1938, p. 174.

Material collected.—In 60 feet, September 8, 1948, 1 specimen. In 100 to 130 feet, 4 to 5 miles out, September 9 to 15, 1948, 6 specimens. In 216 feet, 4.3 miles out, October 6, 1949, 1 specimen. In 295 feet, 5 miles out, October 6, 1949, 1 specimen. In 175 feet, 4 miles out, October 14, 1949, 25 specimens.

Metopa longicornis has been recorded from North Norway and West Greenland. It is a small species measuring about 4 mm. The present records are the first for Alaska. It has been taken off West Greenland between 10 and 130 m.

METOPA SPINICOXA, new species

Figure 6, *g-o*

Material collected.—In 60 to 125 feet, September 8 to 15, 1948, 21 specimens. In 184 feet, 5 miles out, August 30, 1949, 1 specimen. In 175 feet, October 14, 1949, 30 specimens.

Male.—Head equal in length to the first two body segments combined; lateral lobes angular, but not sharply so; eye rather large and very light-colored in alcohol. Antennae somewhat stout. Antenna 1

shorter than antenna 2; peduncular joints decreasing consecutively in length and thickness; flagellum a little longer than the peduncle and composed of about seventeen joints. Antenna 2, third joint one-half the length of the fourth, which is equal in length to the fifth; flagellum short, a little longer than the fifth joint and composed of 11 joints.

Epistome prominent, projected forward and cleft in the center by a deep sinus (fig. 6, *h*). Mandible with 3-jointed palp. Maxilla 1 normal, inner lobe with 1 seta, palp 1-jointed. Maxilla 2 normal. Maxilliped normal. Gnathopod 1 slender; fifth and sixth joints subequal in length; sixth joint with hind margin straight and without palm; seventh joint with a row of setae on inner margin. Gnathopod 2 moderately developed; sixth joint a little wider than the fifth and a little shorter than the second, front and hind margins slightly convex, and widest in the middle; palm oblique, a little shorter than hind margin of joint, convex, bearing low wavy teeth, the central one of which is the largest, defined by an angular process adjacent to which is a shallow sinus bearing a spine; seventh joint fitting palm and bearing a row of spinules on inner margin.

Peraeopods 1 and 2 slender, much alike, 1 the longer. Peraeopod 3 slender and a little longer than peraeopod 4. Peraeopod 4 a little longer than 5, second joint broadly expanded, fourth joint considerably expanded with the hind corner dipping down almost to the end of the fifth joint, fifth joint shorter than the sixth, seventh joint strong and over half the length of the sixth. Peraeopod 5 very much like peraeopod 4.

Uropod 1 reaching a little farther back than 2 and uropod 2 a little farther than 3. Uropod 3, peduncle about equal in length to the ramus and armed on upper margin with a row of spines. Telson narrowly oval in outline, armed on either margin with two spines, and reaching about to the middle of the peduncle of uropod 3. Coxal plates 2 and 3 rather narrow, much deeper than their body segments, and bearing a row of short spines on their hind margin. Length of male about 5 mm.

Female.—The female is like the male, except a little smaller, and the antennae are a little shorter.

Type.—A male, U.S.N.M. No. 96250, taken in 175 feet of water 4 miles off Point Barrow base, Alaska, October 14, 1949, George E. MacGinitie, collector.

Remarks.—This new species is close to *Metopa bruzelii* (Goës) as figured by Sars (1892, pl. 92, fig. 1). *Metopa spinicoxa* is a stouter animal. The second gnathopod is more robust, with the palm armed

with low teeth, the center one of which is the largest. The palm of *bruzelii* is smooth and does not have a sinus adjacent to the defining angle.

METOPA TENUIMANA Sars

Metopa tenuimana Sars, 1892, p. 259, pl. 91, fig. 1.—Stebbing, 1906, p. 181.—Stephensen, 1931, p. 189, fig. 56; 1944b, p. 58.

Material collected.—In 80 to 125 feet, September 8 to 15, 1948, 4 specimens. In 184 feet, 5 miles out, August 30, 1949, 1 specimen. In 175 feet, 4 miles out, October 14, 1949, 6 specimens.

Metopa tenuimana has been recorded from West Norway, Shetland, and East Greenland. It has not heretofore been recorded from Alaska. This is a small species, measuring about 3 mm. and it has been taken down to 40 m.

METOPA PROPINQUA Sars

Metopa propinqua Sars, 1892, p. 264, pl. 93, fig. 1.—Stebbing, 1906, p. 174.—Brüggen, 1909, p. 22, pl. 3, fig. 21.—Shoemaker, 1930b, p. 263.—Stephensen, 1938, p. 168.

Material collected.—In 110 to 125 feet, September 9 to 15, 1948, 1 specimen.

This species has been recorded from Barents Sea, West Norway, Firth of Forth, North Sea, and Gulf of St. Lawrence. It measures about 3 mm. and has been taken as low as 153 m. It is new to the Alaskan fauna.

METOPA ROBUSTA Sars

Metopa robusta Sars, 1892, p. 270, pl. 96, fig. 1.—Stebbing, 1906, p. 173.—Stephensen, 1931, p. 180; 1938, p. 168.

Material collected.—In 175 feet, 4 miles out, October 14, 1949, 1 specimen. In 216 feet, 4.3 miles out, October 6, 1949, 2 specimens.

Metopa robusta has been recorded from North and West Norway, Denmark, Scotland, South and West Greenland. The present records are the first for Alaska. This species measures about 6 mm. and has been taken between 62 and 3,521 m.

METOPELLA NASUTA (Boeck)

Metopa nasuta Boeck, 1871, p. 144.—Sars, 1892, p. 276, pl. 98, fig. 1.—Stebbing, 1906, p. 182.

Metopella nasuta Stephensen, 1931, p. 192; 1938, p. 176; 1940b, p. 30.

Material collected.—In 341 feet, 8 miles out, October 11, 1949, 1 specimen. In 741 feet, 12.1 miles out, August 17, 1949, 1 specimen.

Metopella nasuta has been recorded from North and West Norway, Denmark, Iceland, Scotland, Gulf of St. Lawrence, and West Greenland. The present records are the first for Alaska. This species measures from 3 to 4 mm., and it has been taken between 10 and 250 m.

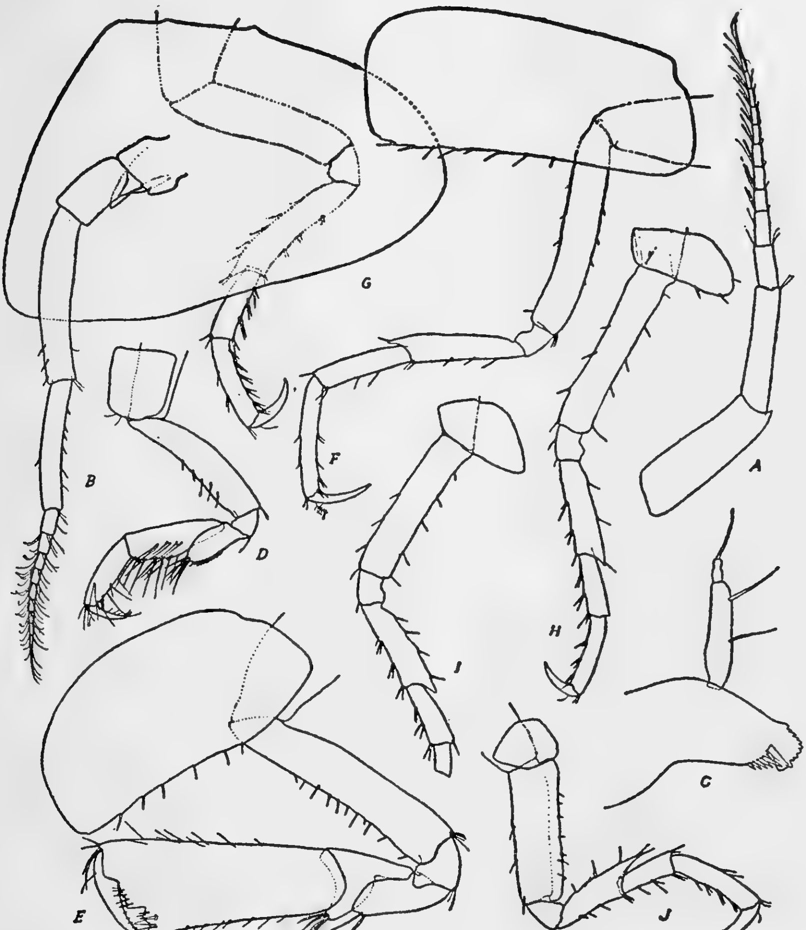

FIG. 7.—*Metopella longimana* (Boeck). Male: *a,* antenna 1; *b,* antenna 2; *c,* mandible; *d,* gnathopod 1; *e,* gnathopod 2; *f,* peraeopod 1; *g,* peraeopod 2; *h,* peraeopod 3; *i,* peraeopod 4; *j,* peraeopod 5.

METOPELLA LONGIMANA (Boeck)

Figure 7, *a-j*

Metopa longimana BOECK, 1871, p. 144.—HANSEN, 1887a, p. 95, pl. 3, figs. 8-8b. —SARS, 1892, p. 273, pl. 97, fig. 1.

Metopella longimana STEBBING, 1906, p. 185.—STEPHENSEN, 1944b, p. 59.

Material collected.—In 100 to 341 feet, 4 to 7.5 miles out, September 1948 and August, September, and October, 1949, 40 specimens. Elson Lagoon, Eluitkak Pass, in 40 feet, August 30, 1948, 1 specimen.

Metopella longimana occurs in the Arctic Ocean, North Atlantic, and North Sea. It has been recorded from Norway, Denmark, East and West Greenland. The present records are the first for Alaska. It measures about 3 mm., and occurs down to about 115 m.

MESOMETOPA NEGLECTA (Hansen)

Figure 8, *a-f*

Metopa neglecta Hansen, 1887a, p. 96, pl. 3, figs. 9-9b.—Stebbing, 1906, p. 184.
Metopella neglecta Sars, 1892, p. 274, pl. 97, fig. 2.—Stephensen, 1931, p. 194; 1938, p. 177.

Material collected.—In 80 to 125 feet, September 8 to September 15, 1948, 4 specimens. In 175 feet, 4 miles out, October 14, 1949, 3 specimens. In 184 feet, 5 miles out, August 30, 1949, 2 specimens. In 216 feet, 4.3 miles out, October 6, 1949, 1 specimen.

This species has been transferred to *Mesometopa*, as the mouthparts agree with that genus as defined by Gurjanova. It is easily identified by the very characteristic shape of the second joint of the fifth peraeopod (fig. 8, *f*). *Mesometopa neglecta* has been recorded from Franz Joseph-Land, West Norway, and West Greenland. The present records are the first for Alaska. This species measures about 3 mm., and it has been taken between 12 and 115 m.

MESOMETOPA GIBBOSA, new species

Figure 8, *g-m*

Material collected.—In 110 to 140 feet, August 21, 1948, 3 specimens. In 80 to 125 feet, September 8, 1948, 4 specimens. In 120 feet, September 15, 1948, 6 specimens. In 180 feet, 5 miles out, August 30, 1949, 1 specimen. In 130 feet, 6 miles out, September 15, 1949, 1 specimen. In 216 feet, $4\frac{1}{3}$ miles out, October 6, 1949, 3 specimens. In 420 feet, 7 miles out, October 9, 1949, 1 specimen. In 6 to 50 m., July 29, 1951, 6 specimens.

Male.—Head with lateral lobes rather sharply angular. Eye large, red in alcohol. Antennae short and slender. Antenna 1 shorter than 2; first peduncular joint thicker and longer than the second, which is over twice as long as the third; flagellum about two-thirds as long as the peduncle and composed of 10 joints. Antenna 2, third peduncular joint expanded proximally with upper margin noticeably raised above that of the second joint; fourth joint longer than either

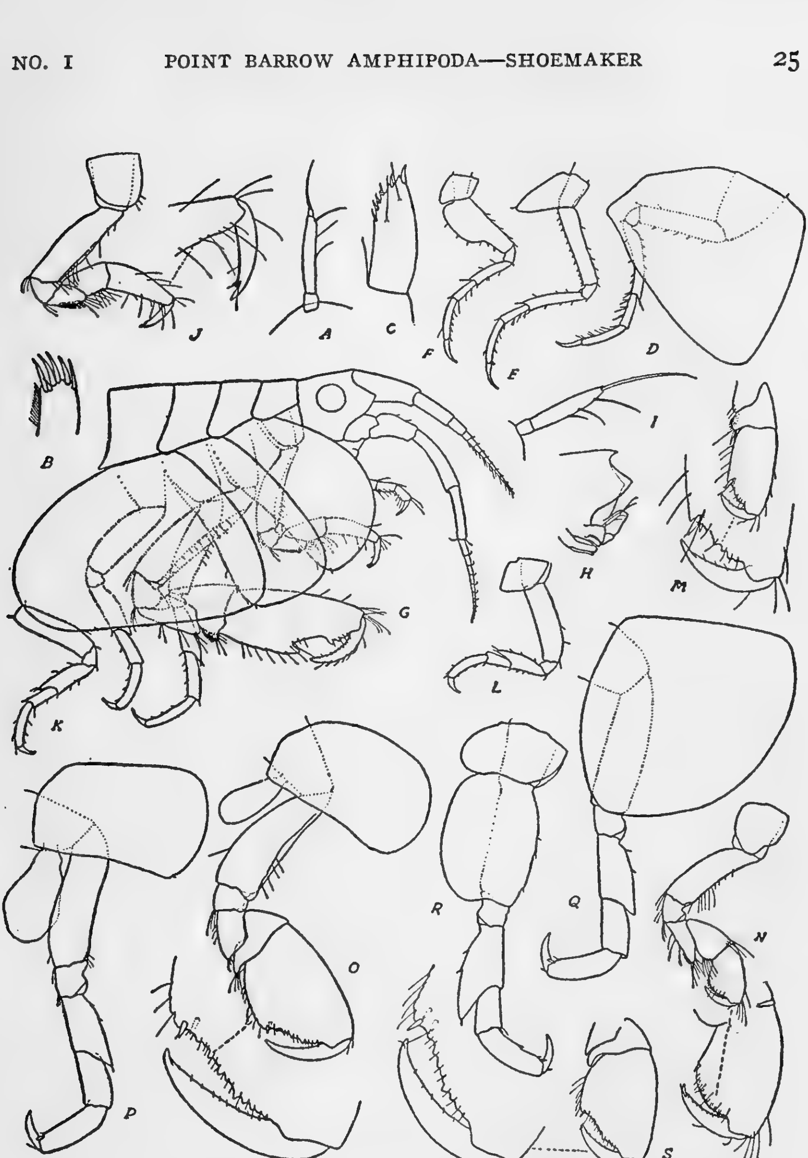

FIG. 8.—*a-f, Mesometopa neglecta* (Hansen). Female: *a*, palp of mandible; *b*, end of outer plate, maxilla 1; *c*, palp of maxilla 1; *d*, peraeopod 2; *e*, peraeopod 4; *f*, peraeopod 5. *g-m, Mesometopa gibbosa*, new species. Male: *g*, front end of animal; *h*, head, showing epistome; *i*, palp of mandible; *j*, gnathopod 1; *k*, peraeopod 4; *l*, peraeopod 5. Female: *m*, gnathopod 2. *n-s, Stenothoe barrowensis*, new species. Male: *n*, gnathopod 1; *o*, gnathopod 2; *p*, peraeopod 1; *q*, peraeopod 2; *r*, peraeopod 4. Female: *s*, gnathopod 2.

the third or fifth; flagellum a little longer than fourth peduncular joint, and composed of 10 or 11 joints. Epistome defined from the upper lip, projecting upward, rounding distally, and defined behind by a deep sinus. Maxilla 1, inner plate with 1 seta; outer plate with 5 long spines and 1 short one; palp 1-jointed and armed distally with spines and setae. Mandibular palp consisting of 1 short and 1 longer joint.

Gnathopod 1 slender; second joint about as long as the fifth and sixth combined; fifth joint nearly four-fifths as long as the sixth; sixth slightly curved and tapering distally; seventh joint slender, curved, and a little over half the length of the sixth joint. Gnathopod 2, second joint equal in length to the sixth; fifth joint a little over half the length of the sixth; sixth joint very little wider than the fifth, the front and hind margins slightly convex, palm equal in length to the hind margin of the joint, defined by a tooth beyond which is a long sinus followed by a prominence bearing several teeth; seventh joint curved and a little shorter than palm, bearing a row of minute setules on the inner margin and a row of short spinules on the outer margin.

Peraeopods 1 and 2 alike in form, but 1 the longer. Peraeopods 4 and 5 alike, second joint not expanded; fourth joint very little expanded and produced behind into a narrow lobe which reaches to about the middle of the fifth joint; seventh joint rather short and stout. Telson long and narrow, without lateral spines, and reaching the middle of the peduncle of uropod 3. Length of male 3 mm.

Female.—Much like the male except in gnathopod 2, which is not as stout as that of the male, sixth joint with palm shorter than the hind margin of the joint, defined by a slight tooth followed by a shallow sinus and then by a slight convex prominence bearing a few low teeth; seventh joint equal in length to the palm and bearing a small forward-pointing tooth distally. Length about equal to that of the male.

Type.—A male, U.S.N.M. No. 95194, dredged at 6 to 50 m., July 29, 1951, off Point Barrow, Alaska.

STENOTHOE BARROWENSIS, new species

Figure 8, *n-s*

Material collected.—In 341 feet, 6 miles out, October 11, 1949, 2 specimens.

Male.—Head with lateral lobes rounding. Eye medium in size and colorless in alcohol. Antennae about equal in length and about half

the length of the body. Antenna 1, first and second joints about equal in length; third joint half the length of the second; flagellum perhaps a little longer than the peduncle and consisting of about 13 joints. Antenna 2, fourth and fifth joints about equal in length; flagellum a little longer than the fifth joint and consisting of 11 joints. Maxilla 1, inner plate with 1 apical seta; outer plate with 5 long and 1 short spine tooth; palp 2-jointed, second joint bearing 7 spines on inner distal margin. Mandible without palp, but having a slender seta in its place; accessory plate with broad, very finely toothed edge like a very fine comb; spine row of about 12 slightly curved spines. Coxal plates shallow and not much deeper than their body segments; fourth coxal plate small.

Gnathopod 1, second joint not as long as the fifth and sixth combined; fourth joint as long as the fifth and produced forward beneath the fifth; fifth joint a little longer than wide and about as wide as the sixth; sixth joint a little longer than wide, and widest in the middle, palm oblique, convex, finely dentate, merging into the hind margin of joint with a scarcely perceptible angle bearing a short spine; seventh joint fitting palm and bearing fine teeth on the inner margin. Gnathopod 2 with second joint about as long as the sixth; fifth joint short and narrowly produced below between the fourth and sixth; sixth joint stout, about two-thirds as wide as long, and widest in the middle; palm oblique, armed with low teeth and defined by a blunt angle bearing a short spine on outside and one on inside; seventh joint slightly curved and about as long as palm. Peraeopods are short and rather stout. Peraeopods 4 and 5 are alike; fourth joint expanded and produced behind nearly to the end of the fifth joint. Telson is without lateral spines and reaches to about the middle of the peduncle of uropod 3. Uropod 3 bears a few small spinules. The male is a little shorter than the female.

Female.—The female closely resembles the male even in the second gnathopods; the antennae, however, are shorter. Length 7 mm.

Type.—A male, U.S.N.M. No. 95193, taken 6 miles off Point Barrow base, Alaska, in 341 feet of water, October 11, 1949, by George E. MacGinitie.

STENOTHOIDES ANGUSTA, new species

Figure 9, *a-i*

Material collected.—In 140 feet, August 21, 1948, 4 specimens ♀. In 110 feet, September 8, 1948, 1 specimen. In 10 to 125 feet, September 8 to 15, 1948, 1 specimen. In 120 feet, September 15, 1948,

8 specimens. In 175 feet, 4 miles out, October 14, 1949, 1 specimen. In 184 feet, 5 miles out, August 30, 1949, 1 specimen. In 216 feet, 4⅓ miles out, October 6, 1949, 3 specimens. Dredged at 6 to 50 m., July 29, 1951 (No. B51-23), 1 specimen.

Female.—Head with lateral lobes rather sharply angular. Eye large, colorless and inconspicuous in alcohol. Antennae short, about

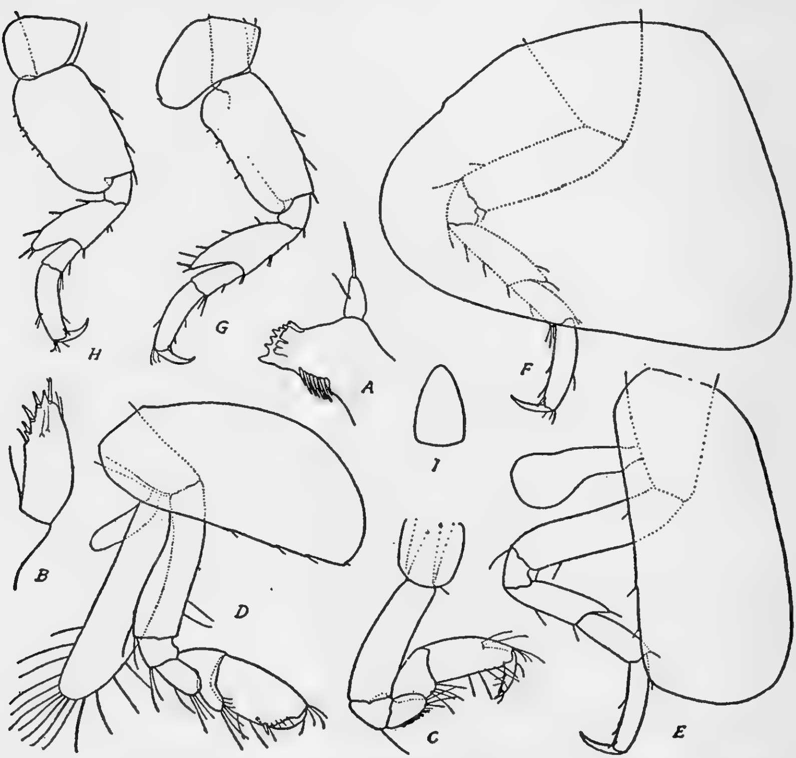

FIG. 9.—*Stenothoides angusta,* new species. Female: *a,* mandible; *b,* palp of maxilla 1; *c,* gnathopod 1; *d,* gnathopod 2; *e,* peraeopod 1; *f,* peraeopod 2; *g,* peraeopod 4; *h,* peraeopod 5; *i,* telson.

one-fourth the length of the body. Antenna 1 about two-thirds as long as antenna 2, first peduncular joint rather stout, flagellum equal in length to the peduncle. Antenna 2 slender; flagellum as long as the peduncle. Maxilla 1, inner plate with 1 seta, outer plate with 5 long spine teeth and 1 short one, palp 1-jointed, the obliquely truncate end armed with 5 spines. Mandible with spine row of 8 spines; accessory plate of right mandible divided into 3 broad teeth; palp consisting of 1 short joint. Second, third, and fourth coxal plates much deeper than their body segments.

Gnathopod 1 rather short and stout; second joint as long as the fifth and sixth combined; fifth joint about two-thirds as long as the sixth and a little wider; sixth joint about twice as long as wide and tapering distally, hind margin with a few slender spines; seventh joint over half the length of the sixth, inner margin bearing a row of very fine teeth and a larger distal tooth. Gnathopod 2, second joint as long as the fifth and sixth combined; fifth joint half the length of the sixth and produced below into a narrow lobe; sixth joint oval, palm oblique, shorter than the hind margin of the joint and defined by a spine, below which on the inner surface is another spine. Peraeopod 4 a little longer than 5, second joint not greatly expanded, twice as long as wide, with a rather shallow distal lobe; fourth joint expanded, with lower distal lobe reaching the end of the fifth joint; seventh joint stout and a little over half the length of the sixth. Peraeopod 5 much like 4, but the second joint is shorter and broader. Telson reaching a little beyond the end of the peduncle of uropod 3, about two-thirds as wide as long, without marginal spines, and with sides converging to a narrow rounding apex. Length 3 mm.

Type.—A female, U.S.N.M. No. 95192, taken 5 miles off Point Barrow, Alaska, in 184 feet of water, August 30, 1949, by George E. MacGinitie.

PROBOLOIDES NORDMANNI (Stephensen)

Figure 10, *a-k*

Metopa nordmanni STEPHENSEN, 1931, p. 187, fig. 55.—GURJANOVA, 1935a, p. 73.

Material collected.—In 150 feet, August 23, 1948, 1 specimen. In 80 to 125 feet, September 8 to 15, 1948, 3 specimens. In 125 feet, 4 to 5 miles out, September 9, 1948, 1 specimen. In 184 feet, 5 miles out, August 30, 1949, 3 specimens. In 217 feet, 7.5 miles out, September 6, 1949, 2 specimens. B51-23, near Point Barrow, dredged in 6 to 50 m., July 29, 1951, 1 specimen.

Stephensen described this species from a single female that was taken in northern Strömfjord, which is on the lower part of the west coast of Greenland. His specimen measured about 5 mm., while the specimens from Alaska are about 4 mm. A male has been figured here, the proportions of the appendages of which vary somewhat from those of the female. The mouthparts of the original female were not dissected out, but the specimens from Alaska have a 2-jointed palp to the first maxilla and a 3-jointed palp to the mandible, which place the species in the genus *Proboloides*. In the male the antennae are longer. Gnathopod 1 in the male is proportionately shorter, the fourth joint not equaling half the length of the fifth, whereas in the

female it is over half the length of the fifth; the sixth joint is not conspicuously wider in the middle, as it is in the female. Gnathopod 2, about as in the female except the coxal plate is widest in the middle. The peraeopods are much like those of the female, though the fourth joint in peraeopods 4 and 5 dips down a little farther behind. The

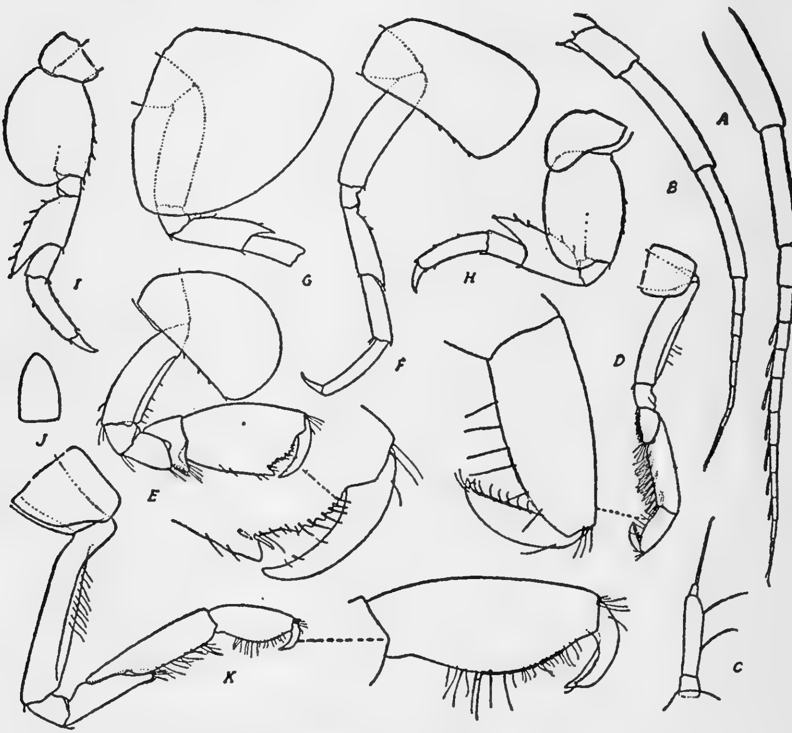

FIG. 10.—*Proboloides nordmanni* (Stephensen). Male: *a*, antenna 1; *b*, antenna 2; *c*, palp of mandible; *d*, gnathopod 1; *e*, gnathopod 2; *f*, peraeopod 1; *g*, peraeopod 2; *h*, peraeopod 4; *i*, peraeopod 5; *j*, telson. Female: *k*, gnathopod 1 of specimen from St. Croix River, New Brunswick.

telson is without spines and reaches back nearly to the end of the peduncle of uropod 3.

This species measures 4 to 5 mm. Gurjanova's specimens were taken at 17 m.

METOPELLOIDES STEPHENSENI Gurjanova

Figure 11, *a-k*

Metopelloides stephenseni GURJANOVA, 1938, pp. 285, 391, fig. 13.

Material collected.—In 150 feet, August 23, 1948, 1 specimen. In

120 feet, 3 miles out, August 8, 1949, 3 specimens. In 217 feet, 7.5 miles out, September 6, 1949, 1 specimen.

This species was described by Gurjanova from the Sea of Japan in 1938. The present records from Alaska are the second of its occurrence.

The first maxilla has 1 seta on the inner lobe and 5 spine teeth on the outer lobe; palp is 1-jointed. Peraeopod 2 is a little longer than 1. Peraeopod 4, second joint not expanded. Peraeopod 5, second joint

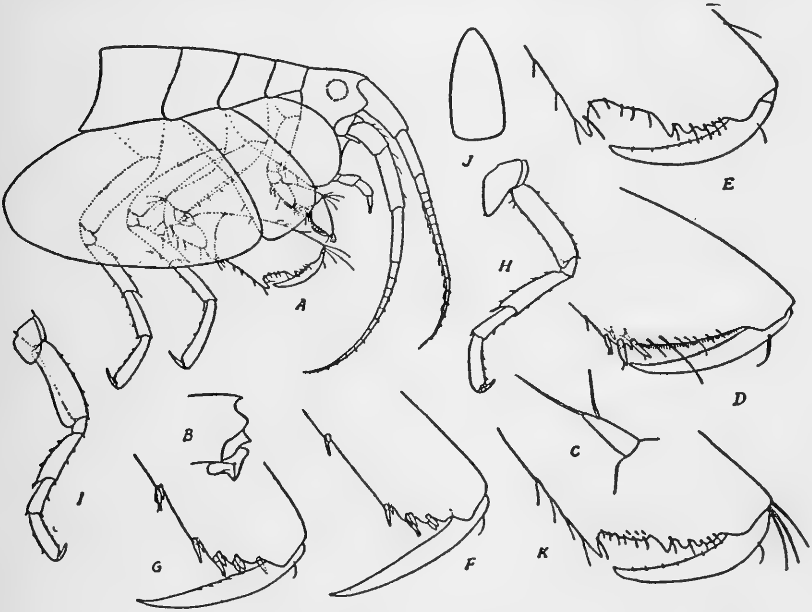

FIG. 11.—*Metopelloides stephenseni* Gurjanova. Male: *a*, front end of animal; *b*, head, showing upper lip and epistome; *c*, palp of mandible; *d*, palm of gnathopod 1, greatly enlarged; *e*, palm of gnathopod 2, greatly enlarged; *f*, end of peraeopod 1; *g*, end of peraeopod 2; *h*, peraeopod 4; *i*, peraeopod 5; *j*, telson. Female: *k*, palm of gnathopod 2.

slightly expanded and produced below into a shallow lobe. All peraeopods with the sixth joint slightly expanded distally and obliquely truncate; the truncate end, which is provided with several pairs of short, stout spines, forming with the dactyl a more or less efficient subchelate grasping organ. A specimen of this species in the National Museum collection, which was identified by Gurjanova, has no spines on the telson. Her figure (1938, fig. 13-2) shows a spine on each lateral margin. The specimens from Point Barrow, which are mature males and females measuring about 6 mm., have no spines on the telson. Gurjanova gives 90 m. for the depth for this species.

METOPELLOIDES TATTERSALLI Gurjanova

Figure 12, *a-e*

Metopelloides tattersalli Gurjanova, 1938, pp. 289, 392, fig. 16.

Material collected.—In 341 feet, 8 miles out, October 11, 1949, 1 specimen.

This species was described by Gurjanova from the Sea of Japan

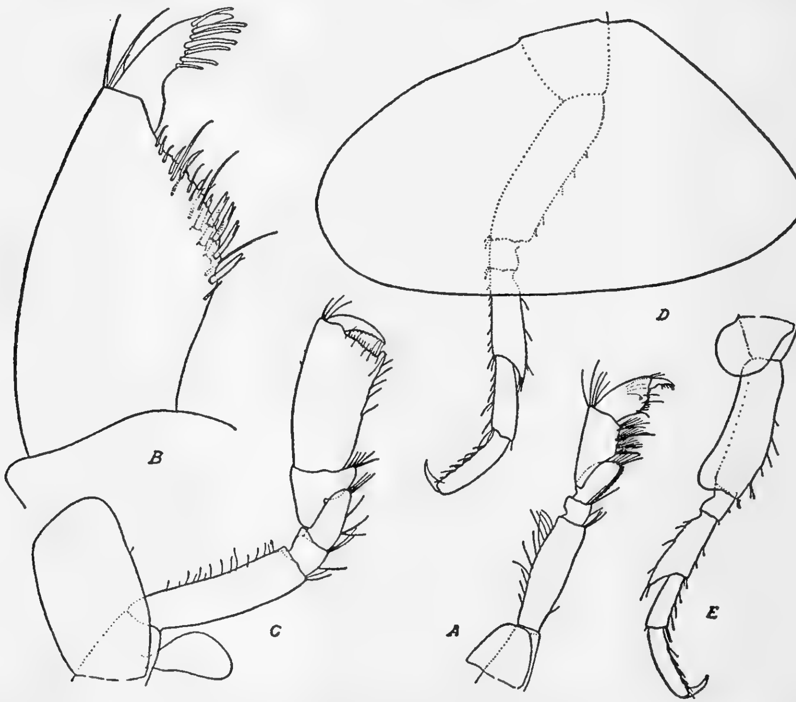

Fig. 12.—*Metopelloides tattersalli* Gurjanova. Male: *a*, gnathopod 1; *b*, sixth and seventh joints of gnathopod 1, greatly enlarged; *c*, gnathopod 2; *d*, peraeopod 2; *e*, peraeopod 5.

in 1938. The present record from Alaska is the second of its occurrence.

In the present male, which is mature and measures about 6 mm., the first gnathopod differs somewhat from that figured by Gurjanova (1938, fig. 16-8). Her specimen, the sex of which is not known, measured only 2.5 mm. and was probably immature.

Gnathopod 1, as shown here in figure 12, *a*, has the sixth joint shorter than the fifth and widening distally. Gnathopod 2 is as shown by Gurjanova. Coxal plate 4 is rather shallow and long. Peraeopod 5 with second joint slightly expanded and produced below

into a shallow lobe. Telson is without spines. Gurjanova gives 62 m. for the depth of this species.

Family THAUMATELSONIDAE

PROTHAUMATELSON CARINATUM, new species

Figure 13, *a-c*

Prothaumatelson SCHELLENBERG, 1931, p. 113.

Material collected.—In 217 feet, 7.5 miles off Point Barrow base, September 6, 1949, 1 specimen. In 120 feet, off Point Barrow base, September 15, 1948, 5 specimens.

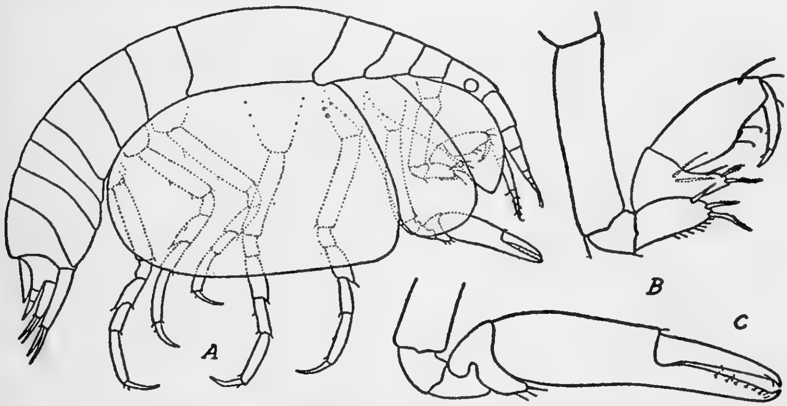

FIG. 13.—*Prothaumatelson carinatum,* new species. Female: *a,* entire animal; *b,* gnathopod 1; *c,* gnathopod 2.

Schellenberg says of *Prothaumatelson* that the second gnathopod is chelate and that the mandibular palp has a reduced number of joints. He places *Thaumatelson nasutum* Chevreux (1913, p. 109) and *Thaumatelson inermis* Chilton (1912, p. 483) in his new genus. With amphipods as small and fragile as these (2 to 3 mm.) it is in many cases difficult to determine the exact number of joints in some of their appendages. The present specimens from Point Barrow have been placed in *Prothaumatelson,* although the mouthparts do not appear to agree in all details with Schellenberg's genus.

Female.—Head not quite as long as the first two body segments combined; lateral lobes triangular with sharply rounding apex. Eye of medium size. Antenna 1, very little shorter than antenna 2, first peduncular joint nearly as long as second and third combined; flagellum about as long as the third peduncular joint and composed of four joints. Antenna 2, fifth joint longer than the fourth;

flagellum not quite as long as the fifth peduncular joint and composed of four joints. Mandible is without palp, but it may have been lost in dissecting. Maxilla 1, inner plate rounding and without setae; outer plate bearing 4 or 5 long spine teeth and 1 short one; palp appears to be 1-jointed, obliquely truncate, and bears 4 or 5 apical teeth or spines. Maxilla 2, inner plate with 3 apical spines and 1 slender lateral spine.

Gnathopod 1 small, second joint as long as the fifth and sixth combined; fourth joint produced a little forward; fifth joint half the length of the sixth and produced below into a forward-projecting lobe; sixth joint widest in the middle, palm longer than hind margin of joint, very oblique, slightly concave, bearing 2 slender spines and armed throughout with very fine teeth; seventh joint slightly curved, as long as palm, and bearing 2 setae on inner margin. Gnathopod 2 slender, second joint not quite as long as the sixth; fifth joint short and produced below into a narrow forward-pointing lobe; sixth joint long and narrow, the sharply produced distal end being opposed by the long and narrow seventh joint forming a chela.

The first and second peraeopods linear and longer than the following peraeopods; the fourth joint very little expanded, and the seventh joint slender and over half the length of the sixth. Peraeopods 3 to 5 slender and subequal in length; fourth joint very little expanded; and the seventh joint over half the length of the sixth. Coxal plates 2 to 4 much deeper than their respective segments. The fourth coxal plate is very large and completely covers all the peraeopods when they are folded.

The metasome segments are produced backward below but not sharply. The first urosome segment is compressed dorsolaterally, forming a thin keel or lamella which does not project backward over the telson. The second and third urosome segments are coalesced. Uropod 1 extends back a little beyond uropod 2, and uropod 2 beyond uropod 3. Very few spinules could be observed on the uropods. The telson is rather long and narrow, lies horizontally, and extends back a little beyond the end of the peduncle of uropod 3. Length of the female figured about 2 mm. The other specimens taken were slightly smaller and were all females.

Type.—A female, U.S.N.M. No. 93547, taken in 120 feet of water off Point Barrow base, Alaska, September 15, 1948, by George E. MacGinitie.

Family ACANTHONOTOZOMATIDAE

ACANTHONOTOZOMA SERRATUM (Fabricius)

Acanthonotozoma serratus SARS, 1893, p. 374, pl. 131, fig. 1.—STEBBING, 1906, p. 218.—STEPHENSEN, 1938, p. 186.

Material collected.—In 125 feet, September 9, 1948, 2 specimens. In 216 feet, October 6, 1949, 1 specimen. In 175 feet, October 14, 1949, 16 specimens.

Acanthonotozoma serratum has been taken at Spitzbergen; Kara Sea; Nova Zembla; Norway; Skagerrak; Iceland; East and West Greenland; Baffin Bay; Port Burwell, Ungava; Labrador; Bay of Fundy; Mount Desert Island, Maine; and off Cape Ann, Mass. It is now for the first time recorded from Alaska.

This species is quite variable. Sars figures the second joint of the last three peraeopods with the lower posterior angle acutely produced. Specimens from the east coast of North America have this lower posterior angle quadrate and bluntly rounding. The specimens from Point Barrow also do not have this angle produced but more or less quadrate and bluntly rounding.

Cape Ann is the most southern record for this species, which reaches a length of 12 mm., and has been recorded as low as 753 m.

ACANTHONOTOZOMA INFLATUM (Kröyer)

Vertumnus inflatus GOËS, 1866, p. 523, pl. 38, fig. 11.
Acanthonotozoma inflatum STEBBING, 1894, p. 32, fig. 6; 1906, p. 219.—STEPHENSEN, 1931, p. 211; 1938, p. 188, fig. 22; 1944b, p. 61.

Material collected.—In 150 feet, August 23, 1948, 5 specimens. In 420 feet, 7 miles out, August 9, 1949, 2 specimens. In 213 feet, 4 miles out, October 6, 1949, 1 specimen. In 216 feet, 4⅓ miles out, October 6, 1949, 1 specimen. In 152 feet, 3.5 miles out, October 14, 1949, 1 specimen. In 175 feet, 4 miles out, October 14, 1949, 20 specimens.

Acanthonotozoma inflatum, as with the preceding species, is quite variable in some of its characters. Stebbing's figure (1894, fig. 6) shows the lower posterior angle of the second joint of the last three peraeopods sharply produced. Goës's figure (1866, pl. 38, fig. 11) shows the second joint with an evenly rounding lower posterior margin. The specimens of this species from the east coast of America have the lower posterior corner of the second joint about quadrate and narrowly rounding. The specimens taken at Point Barrow resemble Goës's figure, but have the lower posterior border of the second joint broadly rounding without any angle whatever.

This species has been taken in Kara Sea; Spitzbergen; East and West Greenland; Baffin Bay; Labrador; Gulf of St. Lawrence; Atlantic coast of Nova Scotia; Collinson Point and Kotzebue Sound, Alaska; off Diomede Island; and now from Point Barrow. Stebbing gives the length of this species as 6.5 to 18.5 mm., and the depth as 10 to 300 m.

ODIUS CARINATUS (Bate)

Odius carinatus Sars, 1893, p. 381, pl. 133, fig. 2.—Stebbing, 1906, p. 211.—Stephensen, 1938, p. 184; 1944b, p. 59.

Material collected.—In 216 feet, 4.5 miles out, October 6, 1949, 1 specimen. In 175 feet, 4 miles out, October 14, 1949, 1 specimen.

Odius carinatus has been taken at Spitzbergen; North, West, and South Norway; East coast of England; Iceland; East and West Greenland; off Newfoundland; Pribilof Islands; and now from Point Barrow. It measures about 5 mm. and has been recorded down to 201 to 204 m.

Family OEDICEROTIDAE

ACANTHOSTEPHEIA MALMGRENI (Goës)

Amphithonotus malmgreni Goës, 1866, p. 526, pl. 39, fig. 17.
Acanthostepheia malmgreni Stebbing, 1906, p. 254.—Stephensen, 1938, p. 217, fig. 25; 1944b, p. 70.

Material collected.—Taken on beach at Point Barrow base, September 24, 1950, 20 specimens.

This is probably a circumpolar species. It has been recorded from New Siberian Islands, Kara Sea, Franz Josef Land, Spitzbergen, Iceland, East Greenland, West Greenland, Baffin Bay, Dolphin and Union Strait, Alaska, Bering or Okhotsk Sea.

In the U. S. National Museum there are specimens from Labrador; Hudson Bay; Ellesmere Island; and Cape York, North Greenland. This species reaches a length of 45 mm., and has been recorded from the beach down to about 550 m.

ACANTHOSTEPHEIA BEHRINGIENSIS (Lockington)

Oedicerus behringiensis Lockington, 1877, p. 47.
Acanthostepheia behringanus Holmes, 1904a, p. 315, pl. 36, figs. 25-28.
Acanthostepheia pulchra + *Acanthostepheia behringiensis* Stebbing, 1906, p. 254, 726.
Acanthostepheia pulchra Shoemaker, 1920, p. 11.
Acanthostepheia behringiensis Stephensen, 1938, p. 218, fig. 25 (2).

Material collected.—Taken in Eluitkak Pass, Elson Lagoon, in 30 to 40 feet, August 8 and September 8, 1948, 5 specimens. Washed

ashore at Point Barrow base, August, September, and October, 1949, 12 specimens.

This is a widely distributed arctic species, probably circumpolar. It was described by W. N. Lockington in 1877 from specimens taken on the west coast of Alaska, north of Bering Strait (1877 [1876], p. 47). Five specimens were taken off Point Barrow by the Point Barrow Expedition, 1881-1883, but were identified as *Acanthostepheia malmgreni* Goës. *Acanthostepheia behringiensis* is a large species, reaching a length of at least 37 mm. and it has been taken as low as 60 m.

MONOCULODES BOREALIS Boeck

Monoculodes borealis Sars, 1892, p. 298, pl. 106, fig. 2.—Stebbing, 1906, p. 262. —Stephensen, 1931, p. 243; 1938, p. 225; 1944b, p. 72.

Material collected.—Washed ashore, August 21, 1949, 5 specimens, and September 22, 1949, 7 specimens. From screen trap through ice, 1.8 miles out, March 29, 1950, 1 specimen.

This is a circumpolar species which dips down into the cold North Atlantic. The present records are the first for Alaska. It reaches a length of 10 mm., and has been recorded between 80 and 200 m.

MONOCULODES LATIMANA (Goës)

Monoculodes latimanus Sars, 1892, p. 304, pl. 108, fig. 1.—Stebbing, 1906, p. 264.—Stephensen, 1931, p. 244; 1938, p. 226; 1944b, p. 73.

Material collected.—In 110 feet, off Point Barrow base, September 8, 1948, 1 specimen. In 120 feet, 3 miles out, August 8, 1949, 1 specimen. In 741 feet, 12.1 miles out, August 17, 1949, 1 specimen.

This is a circumpolar species that dips down into the cold North Atlantic. It has not heretofore been recorded from Alaska. It measures about 7 mm., and has been recorded from shallow water down to about 120 m.

MONOCULODES LONGIROSTRIS (Goës)

Monoculodes longirostris Sars, 1892, p. 306, pl. 108, fig. 3.—Stebbing, 1906, p. 260.—Stephensen, 1931, p. 242; 1938, p. 223; 1944b, p. 72.—Gurjanova, 1935a, p. 75.

Material collected.—From beach at Point Barrow base, September 28, 1950, 1 specimen.

This is probably a circumpolar species that dips down into the North Atlantic to the Kattegat and the Gulf of St. Lawrence. It has been recorded from Bernard Harbor, Northwest Territories, but not

heretofore from Alaska. It reaches a length of 12 mm., and has been taken as low as 887 m.

MONOCULODES PACKARDI Boeck

Monoculodes packardi SARS, 1892, p. 307, pl. 109, fig. 1.—STEBBING, 1906, p. 266. —STEPHENSEN, 1931, p. 247; 1938, p. 229; 1940b, p. 40.

Material collected.—Taken in screen trap through hole in ice in 80 feet, April 15, 1950, 2 specimens. From beach at Point Barrow base, September 24, 1950, 1 specimen.

This species has been recorded from Gulf of St. Lawrence, Iceland, Norway, Nova Zembla, and Danish waters. It is new to the Alaskan fauna. It reaches a length of 12 mm., and has been taken from shallow water down to 235 m.

MONOCULODES SCHNEIDERI Sars

Monoculodes schneideri SARS, 1895, p. 692, Suppl., pl. VI, fig. 1.—STEBBING, 1906, p. 263.—GURJANOVA, 1935a, p. 76.—STEPHENSEN, 1938, p. 226.

Material collected.—Washed ashore at Point Barrow base August 21, 1949, 2 specimens.

This species has been recorded from North Norway; White Sea; Franz Joseph Land; Gulf of St. Lawrence; Cape Smyth, Alaska; and Kara Sea. It measures about 6 mm. and has been taken from shallow water down to about 60 m.

ACEROIDES LATIPES (Sars)

Aceropsis latipes SARS, 1892, p. 341, pl. 120, fig. 2.
Aceroides latipes STEBBING, 1906, p. 255.—SHOEMAKER, 1920, p. 11.—STEPHENSEN, 1931, p. 239; 1938, p. 219; 1944b, p. 70.—GURJANOVA, 1935a, p. 75.

Material collected.—Washed ashore July 26, 1949, 1 specimen, and September 20, 1949, 1 specimen. From screen trap through hole in ice, 1.8 miles out in 80 feet, March 29, 1950, 1 specimen.

This species has been recorded from West Greenland, East Greenland, North Norway, Kara Sea, New Siberian Islands, and Alaska. It measures about 5 mm., and has been recorded as low as 660 m.

Family TIRONIDAE

TIRON SPINIFERUM (Stimpson)

Lysianassa spinifera STIMPSON, 1854, p. 49.
Tiron acanthurus LILLJEBORG, 1865, p. 19.—SARS, 1893, p. 399, pl. 140.—STEBBING, 1906, p. 276.—SHOEMAKER, 1930b, p. 291.—STEPHENSEN, 1938, p. 231; 1944b, p. 76.

Material collected.—In 216 feet, 4⅓ miles out, October 6, 1949, 3 specimens.

This species has been recorded from the White Sea, Spitzbergen, North and West Norway down to the Skagerak, Iceland, Scotland, East and West Greenland, Gulf of St. Lawrence, off Nova Scotia, and Sea of Japan. There are specimens in the United States National Museum from the Bay of Fundy. The present specimens, which are not fully mature, are the first to be recorded from Alaska.

Lysianassa spinifera was described by William Stimpson from Grand Manan, Bay of Fundy, in 1954. He gives no figures, but his description, as far as it goes, applies accurately to *Tiron acanthurus* Lilljeborg. It is unfortunate that the specific name *acanthurus*, which has been in use so long, will have to be put into synonymy, but the law of priority should prevail. This species reaches a length of 8 or 9 mm., and has been taken down to about 120 m.

SYRRHOË CRENULATA Goës

Syrrhoë crenulata Sars, 1893, p. 390, pl. 136.—Stebbing, 1906, p. 282.—Shoemaker, 1930b, p. 291.—Stephensen, 1938, p. 234; 1944b, p. 76.

Material collected.—In 216 feet, 4.3 miles out, October 6, 1949, 3 specimens.

Syrrhöe crenulata has been recorded from Franz Joseph Land; Nova Zembla, Kara Sea; White Sea; Murman Coast; Spitzbergen; North and West Norway; Iceland; East and West Greenland; Newfoundland; Gulf of St. Lawrence; and the Sea of Japan. There are specimens in the United States National Museum from the Bay of Fundy; Casco Bay, Maine; coast of Massachusetts; off Marthas Vineyard; Block Island, R. I.; 15 miles north of Big Diomede Island; and mouth of Kotzebue Sound, Alaska. This species reaches a length of about 10 mm., and has been taken as low as 300 m.

Family CALLIOPIIDAE

APHERUSA GLACIALIS (Hansen)

Amphithopsis glacialis Hansen, 1887a, p. 137, pl. 5, fig. 6a-c.
Apherusa glacialis Stebbing, 1906, p. 307.—Stephensen, 1931, p. 277, fig. 79; 1944b, p. 81.

Material collected.—Found clinging to under side of ice cakes at Point Barrow base, August 29, 1948, 12 specimens.

Apherusa glacialis is probably a circumpolar species, but has not heretofore been recorded from Alaska. It has been recorded from East and West Greenland, Gulf of St. Lawrence, and Northeast

Canada. This species measures from 7 to 10 mm., and occurs from shallow water down to 300 m.

Family PLEUSTIDAE

PLEUSTES PANOPLA (Kröyer)

Figure 14, *a*

Amphithoe panopla KRÖYER, 1838, p. 270, pl. 2, fig. 9.
Amphithonotus cataphractus STIMPSON, 1854, p. 52.
Pleustes panoplus HANSEN, 1887a, p. 119.—SARS, 1893, p. 344, pl. 121.—ORTMANN, 1901, p. 150.—HOLMES, 1905, p. 488, text fig.; pl. 7, fig. 3.—STEBBING, 1906, p. 310.—SHOEMAKER, 1930b, p. 309.—STEPHENSEN, 1938, p. 253, fig. 28; 1944a, p. 4; 1944b, p. 48.

Material collected.—In 80 feet, September 9, 1948, 1 specimen. In 37 feet, 0.75 mile out, in screen trap through hole in ice, March 10, 1950, 1 specimen. From beach at Point Barrow base, September 28, 1950, 1 specimen.

Pleustes panopla is a circumpolar species that dips down into the cold waters of the North Atlantic and North Pacific. There are specimens of this species in the U. S. National Museum from Labrador, Gulf of St. Lawrence, Bay of Fundy and south of Marthas Vineyard (*Fish Hawk* station 987, 40° 54′ N., 70° 48′ 30″ W.); and in the Pacific from Bering Sea and off Japan (*Albatross* station 4828, 37° 23′ N., 137° 36′ E.). It was recorded from the Sea of Japan in 1930 by A. N. Derjavin.

William Stimpson in 1854 described *Amphithonotus cataphractus* from Grand Manan, Bay of Fundy, but gave no figures. His description applies very well to *Pleustes panopla* (Kröyer), which occurs at Grand Manan. I have examined many specimens of *P. panopla* from New England, Gulf of St. Lawrence, Bay of Fundy, and Labrador, and they all agree in all characters with a typical specimen from Grand Manan, the second gnathopod of which is here figured. The palm of this gnathopod is evenly convex, the proximal end passing into the three rounding lobes, which form a protruding angle with the palm, and each of which bears on its inside surface a group of spines; the seventh joint fits the convex palm and reaches the first group of spines. Stebbing considered the three spinose lobes to be a part of the palm, but believed that Sars regarded them as a part of the hind margin of the sixth joint. Sars was undoubtedly correct. The first gnathopod is like the second, but is not so stout and the characters are less pronounced. The specimens from Alaska, Bering Sea, and Japan agree with those from Grand Manan. Cecchini (Mem. 142, R. Comitato Talassografico Italiano, p. 8, pl. 2, fig. 5) figured the second

gnathopod of a specimen from Spitzbergen which she identified as *Pleustes cataphractus,* and her figure agrees with the corresponding appendage of the specimen from Grand Manan. The early figures of this species are crude and show very little detail and are of little help in these matters. Bate's (1862, pl. 9, figs. g, h, i) figure of the second gnathopod shows a protruding angle bearing two small lobes at the

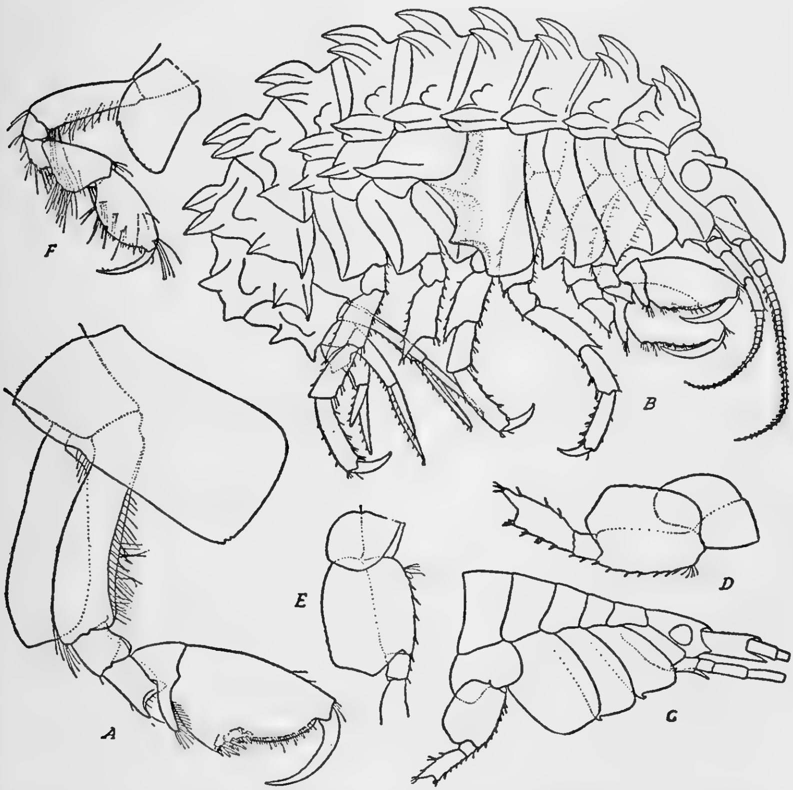

FIG. 14.—*a, Pleustes panopla* (Kröyer), Male: gnathopod 2. *b, Pleustes panopla,* variety *angulata,* new variety, Male: entire animal. *c-e, Sympleustes uncigera* Gurjanova. Male: *c,* front end of animal; *d,* peraeopod 4; *e,* peraeopod 5. *f, Sympleustes kariana* Stappers. Male: gnathopod 1.

proximal end of the palm, but his figure of the entire animal is so crude that it bears little resemblance to *P. panopla.* Sar's figure (1893, pl. 121, fig. p^2) does not show a protruding angle, but figures the three groups of spines as occupying slight depressions in the hind margin of the joint. In typical *panopla* the lower margins of the first four coxal plates are evenly rounding, and the mesosome segments bear median dorsal carinae but no teeth or other protuberances except

low, backward-pointing ridges at the lower end of the segments just above the coxal plates.

The waters around Alaska and Bering Sea are inhabited by an assortment of forms which appear to be varieties of the typical *panopla*. E. Gurjanova (1938, p. 313, fig. 28) has figured and described one of these varieties, which she has named variety *obtusirostris*. The animal she has figured is an extreme case, having the rostrum decidedly truncate. This is a character which varies from the extreme to almost no truncation at all. There are forms possessing carinae and teeth in a number of different arrangements and combinations. A form has been here figured with an extreme assortment of teeth, knobs, and ridges, which is being named *Pleustes panopla*, var. *angulata* (fig. 14, *b*).

Type.—U.S.N.M. No. 92422. This specimen, a female, measuring about 10 mm., with fully developed marsupial plates, was taken by the Fisheries steamer *Albatross*, at station 4804 (46° 42′ N., 151° 47′ E.) at 229 fathoms, June 24, 1906. Gurjanova (1938, p. 313, fig. 27) has figured a variety which is much like the one here figured; however, she identified it as *Pleustes cataphractus* Stimpson. It is difficult to decide where varieties end and species begin in such cases as these.

Pleustes panopla reaches a length of 27 mm. and occurs from the littoral down to about 1026 m.

PLEUSTES MEDIA (Goës)

Paramphithoe media Goës, 1866, p. 523, pl. 38, fig. 13.—Boeck, 1871, p. 176.
Pleustes medius Boeck, 1876, p. 302.—Stebbing, 1906, p. 311.—Shoemaker, 1930b, p. 307, fig. 38.—Gurjanova, 1935a, p. 76.—Frost, 1936, p. 6.—Stephensen, 1938, p. 250. fig. 27.

Material collected.—In 420 feet, 7 miles out, August 9, 1949, 3 specimens. In 217 feet, 7.5 miles out, September 6, 1949, 1 specimen. In 295 feet, 5 miles out, October 6, 1949, 1 specimen.

Pleustes media was described from Spitzbergen in 1866. It was next recorded from the White Sea by Jarzynsky in 1870. In 1930 a single specimen was taken in the Gulf of St. Lawrence by the Cheticamp Expedition. In 1935 Gurjanova recorded it from the Kara Sea. A single specimen was recorded from the Newfoundland waters by Nancy Frost in 1936.

Five specimens of this rarely seen amphipod were taken in the offshore waters at Point Barrow in 1949. There are in the United States National Museum two specimens of *Pleustes media* taken by the Fisheries steamer *Albatross* in 1885, one at station 2461 (45° 47′

00″ N., 54° 13′ 30″ W.), and one at station 2490 (45° 27′ 30″ N., 58° 27′ 45″ W.); and 3 specimens in 1890 at station 3252 (57° 22′ 20″ N., 164° 24′ 40″ W.). One fine specimen was taken in Constantine Harbor, Alaska, in 1873, by Dr. W. H. Dall. *Pleustes media* measures about 8 mm., and has been taken between 40 and 85 m.

PARAPLEUSTES PULCHELLA (Kröyer)

Paramphithoe pulchellus Sars, 1893, p. 346, pl. 122, fig. 1.
Neopleustes pulchellus Stebbing, 1906, p. 312.—Shoemaker, 1930b, p. 306.
Parapleustes pulchellus Stephensen, 1938, p. 255; 1944a, p. 4.

Material collected.—In 341 feet of water, 6 miles out, October 11, 1949, 1 specimen.

This is an arctic species that dips down into the North Atlantic and North Pacific. It is common off the New England coast, and has been taken off Newfoundland and in the Gulf of St. Lawrence. Fine specimens were taken in 1940 in Pavlof Bay, south side of the Alaska Peninsula, by Dr. Waldo L. Schmitt while on the Alaska king crab investigation. *Parapleustes pulchella* reaches a length of 17 mm., and has been recorded from shallow water down to 300 m.

SYMPLEUSTES PULCHELLA (Sars)

Amphithopsis pulchella Sars, 1885, p. 175, pl. 14, fig. 6.
Parapleustes pulchellus Sars, 1893, p. 359, pl. 126, fig. 2.
Sympleustes pulchellus Stebbing, 1906, p. 319.—Stephensen, 1938, p. 263; 1940b, p. 46; 1944a, p. 5.

Material collected.—In 125 feet, 4 to 5 miles out, September 9, 1948, 2 specimens. In 438 feet, 12.1 miles out, August 17, 1949, 1 specimen. In 453 feet, 8 miles out, October 11, 1949, 1 specimen.

Sympleustes pulchella is an arctic species that has been taken at northern Norway, Murman Coast, south of Spitzbergen, east of Iceland, and East and West Greenland. The present records are the first for Alaska. This species measures about 7 mm., and has been taken as low as 763 m.

SYMPLEUSTES UNCIGERA Gurjanova

Figure 14, *c-e*

Sympleustes uncigera Gurjanova, 1938, p. 320, fig. 33.

Material collected.—In 60 feet, September 8, 1948, 1 specimen. In 125 feet, 4 to 5 miles out, September 9, 1948, 25 specimens. In 420 feet, 7 miles out, August 9, 1949, 4 specimens. In 184 feet, 5 miles out, August 30, 1949, 6 specimens. In 477 feet, 16 miles out, Sep-

tember 6, 1949, 1 specimen. In 216 feet, 4.3 miles out, October 6, 1949, 30 specimens. In 152 feet, 3.5 miles out, October 14, 1949, 2 specimens. In 175 feet, 4 miles out, October 14, 1949, 35 specimens.

The present records are the second of the occurrence of this species, which was described by Gurjanova from the Sea of Japan in 1938. It appears to be fairly abundant in the waters around Point Barrow. Some figures of an Alaskan specimen are here given in order to help establish the identity of the species.

The lateral angles of the head are produced sharply forward. The lower distal margin of the first joint of the first antenna is produced forward. The lower hind corner of the first three coxal plates is produced into a prominent hook. The lower hind margin of the second joint of the last three peraeopods is obliquely truncate. The telson extends a little beyond the peduncle of the third uropod. The largest specimen in the present collection measures about 10 mm. This species has been taken down to about 125 m.

SYMPLEUSTES KARIANA Stappers

Figure 14, *f*

Sympleustes karianus Stappers, 1911, p. 48, pl. 2, figs. 10-20.

Material collected.—In 110 feet, September 9, 1948, 1 specimen. In 175 feet, 4 miles out, October 4, 1949, 1 specimen.

The lateral lobes of the head are rather broadly rounding. The first three coxal plates do not have a hook at the lower hind corner, but only a shallow indentation bearing a setule. The second joint of the last three peraeopods has the hind margin evenly rounding below and not truncate as in *Sympleustes uncigera* Gurjanova. There are no dorsal teeth. At the outer distal end of the peduncle of uropod 1 there is a small spine, which is no larger than the spines on the outer margin of the peduncle. The telson extends a little beyond the peduncle of uropod 3. There is no hook or tooth at the lower hind corner of the third metasome segment.

The present record appears to be the second of the occurrence of this species, which was described from the Kara Sea. It measures about 5 mm., and has been taken at 165 m.

Family PARAMPHITHOIDAE

PARAMPHITHOE POLYACANTHA (Murdoch)

Acanthozone polyacantha Murdoch, 1885a, p. 520; 1885b, p. 146, pl. 1, fig. 4.

Paramphithoe polyacantha Stebbing, 1906, p. 325.—Gurjanova, 1935a, p. 76.—Stephensen, 1938, p. 269, fig. 30.

Paramphithoe polyacantha Brüggen, 1909, p. 32, pl. 1, fig. 3.

Material collected.—In 35 feet in Eluitkak Pass, Elson Lagoon, August 6, 1948, 1 specimen. In 130 feet, 4 miles out, August 9, 1949, 1 specimen. In 420 feet, 7 miles out, August 9, 1949, 2 specimens. Washed ashore September 26, 1949, 1 specimen, and October 5, 1949, 1 specimen. In 40 feet in Eluitkak Pass, Elson Lagoon, August 1, 1950, 2 specimens.

Paramphithoe polyacantha was described by John Murdoch from specimens taken off Point Franklin, Alaska, in 13.5 fathoms, in 1885, by the Point Barrow Expedition of 1881-1883. It has since been recorded from Nova Zembla, Kara Sea, and New Siberian Islands. The largest specimen in the present collection, a female, measures about 34 mm. This species has been recorded as low as 24 m.

Family ATYLIDAE

ATYLUS CARINATUS (Fabricius)

Atylus carinatus Sars, 1893, p. 471, pl. 166, fig. 1.—Stebbing, 1906, p. 328.—Gurjanova, 1932, p. 167; 1935a, p. 76.—Stephensen, 1938, p. 276; 1944b, p. 91.

Material collected.—In 10 feet, 300 feet out, July 20, 1948, 4 specimens. In 30 to 40 feet in Eluitkak Pass, Elson Lagoon, August 18, 1948, 1 specimen. In 30 to 40 feet, September 10, 1948, 3 specimens. Washed ashore September 26, 1949, 1 specimen. From beach at Point Barrow, September 28, 1950, 2 specimens.

Atylus carinatus is a circumpolar species that occasionally dips down into the cold northern waters. It has been recorded from East Greenland and James Bay, which is in the southern end of Hudson Bay.

There are in the U. S. National Museum specimens from Pendulum Island and Shannon Island, Northeast Greenland; Disko Island, West Greenland; Davis Strait; Frobisher Bay, east coast of Baffin Land; Collinson Point, Alaska; Dobbin Bay, East Ellesmere Island; Melville Island, Northwest Territory, Canada; Kotzebue Sound and Port Clarence, Alaska. This species reaches a length of 43 mm., and has been taken down to about 50 m.

NOTOTROPIS BRÜGGENI Gurjanova

Nototropis brüggeni Gurjanova, 1938, p. 325, figs. 36, 37; p. 397.

Material collected.—In 120 feet, 3 miles out, August 8, 1949, 1 specimen.

This species was described in 1938 from the Sea of Japan by E. Gurjanova. The present specimen, which measures about 20 mm.,

constitutes the second record of the occurrence of this species. It is, however, well represented in the collection of the U. S. National Museum, where there are specimens from Bay of Islands, Newfoundland; Port Franklin and Kiska Island, Alaska; Bering Island; and Indian Point, Siberia. *Nototropis brüggeni* has been taken between 45 and 80 m.

Family EUSIRIDAE

RHACHOTROPIS ACULEATA (Lepechin)

Tritropis aculeata HANSEN, 1887a, p. 139, pl. 5, fig. 7.
Rhachotropis aculeata SARS, 1893, p. 424, pl. 149.—STEBBING, 1906, p. 348.—SHOEMAKER, 1930b, p. 316.—GURJANOVA, 1938, p. 329.—STEPHENSEN, 1940b, p. 48; 1944b, p. 96.

Material collected.—In 100 to 150 feet, August 21, 1948, 3 specimens. In 150 feet, August 23, 1948, 7 specimens. In 110 and 125 feet, September 8 and 9, 1948, 2 specimens. In 213 feet, 4 miles out, October 6, 1949, 1 specimen. In 138 feet, 3.5 miles out, August 1, 1950, 1 specimen. At Point Barrow base, June 4, 1951, 1 specimen. Dredged at 75 m., July 26, 1951, 4 specimens.

Rhachotropis aculeata is a circumpolar species that dips down into the North Atlantic and North Pacific. On the coast of the United States it has been recorded from Cape Ann, Mass., and on the Asiatic coast from the Sea of Japan by Gurjanova. The International Polar Expedition to Point Barrow, 1881-1883, took it at Point Franklin, Alaska. This species reaches a length of 44 mm. and has been taken down to 250 m.

EUSIRUS CUSPIDATUS Kröyer

Eusirus cuspidatus SARS, 1893, p. 416, pl. 146.—STEBBING, 1906, p. 339.—STEPHENSEN, 1940a, p. 283; 1944b, p. 95.

Material collected.—In 150 feet, August 23, 1948, 1 specimen. In 125 feet, September 9, 1948, 1 specimen. In 130 feet, 4 miles out, August 9, 1949, 1 specimen. In 420 feet, 7 miles out, August 9, 1949, 5 specimens. In 741 feet, 12.1 miles out, August 17, 1949, 1 specimen. In 217 feet, 7.5 miles out, September 6, 1949, 1 specimen. In 246 feet, 7 miles out, September 8, 1949, 1 specimen. In 216 feet, 4.3 miles out, October 6, 1949, 1 specimen. In 295 feet, 5 miles out, October 6, 1949, 1 specimen. In 341 feet, 6 miles out, October 11, 1949, 10 specimens. In 175 feet, 4 miles out, October 14, 1949, 9 specimens (young). In 204 feet, August 5, 1950, 1 specimen.

This species has been recorded from North Norway, Spitzbergen, White Sea, Barents Sea. Franz Joseph Land, northern Russia, Nova

Zembla, New Siberian Islands, East and West Greenland, and Grand Manan.

In the U. S. National Museum there are specimens of this species from off Nova Scotia (45° 22′ N., 58° 43′ W.); off Newfoundland; Port Burwell, Labrador; Cook Island, Unalaska; Kotzebue Sound and Point Barrow, Alaska. The largest specimen in the present collection measures 45 mm. This species has been recorded from shallow water down to 400 m.

ROZINANTE FRAGILIS (Goës)

Paramphithoe fragilis Goës, 1866, p. 524, pl. 39, fig. 16.
Tritropis fragilis Boeck, 1871, p. 160.
Rozinante fragilis Stebbing, 1906, p. 354.—Shoemaker, 1930b, p. 325, fig. 45.—Stephensen, 1940a, p. 291, fig. 33; 1944b, p. 99.

Material collected.—Taken from the stomach of arctic cod (*Boreogaidus saida*) caught in a lath trap through hole in ice in 21 feet of water, 0.5 mile out, February 3, 1950, 2 specimens.

Rozinante fragilis is probably a circumpolar species, which, in the western Atlantic, has been recorded as far south as the Gulf of St. Lawrence. It reaches a length of 22 mm., and has been recorded from shallow water down to 400 m.

Family GAMMARIDAE

GAMMARUS (RIVULOGAMMARUS) LACUSTRIS Sars

Gammarus lacustris Sars, 1863, p. 210.—Smith, 1871, p. 453.—Schellenberg, 1934, p. 210, figs. 1-4.
Gammarus limnaeus Smith, 1874, p. 651, pl. 2, figs. 6, 7.—Hubricht, 1943, p. 684.
Gammarus pulex Sars, 1895, p. 503, pl. 177, fig. 2.
Gammarus (*Rivulogammarus*) *lacustris* Schellenberg, 1937, p. 490, figs. 2-6.—Stephensen, 1940a, p. 353, figs. 50, 51.

Material collected.—Lake at Anaktuvuk Pass, Brook Range, Alaska, August 1949, 25 specimens.

Gammarus lacustris is a fresh-water species that inhabits cold lakes of northern Europe and northern America. It is found in the cold lakes of Alaska, in Canada, and the northern parts of the United States from Maine to Washington, and has been recorded by Leslie Hubricht from Michigan, Illinois, Missouri, Arkansas, and Oklahoma. It reaches a length of 22 mm.

GAMMARUS LOCUSTA (Linn.) var. SETOSA Dementieva

Gammarus locusta var. *setosa* Dementieva, 1931, p. 80.—Stephensen, 1940a, p. 321, fig. 41; 1944b, p. 109, fig. 8.

Material collected.—Near shore at Point Barrow base, July 15, 1948, 1 specimen. In shallow water, 300 feet from shore, July 20, 1948, 5 specimens. In 5 to 40 feet in Eluitkak Pass, and west side of Elson Lagoon, August 10, 1948, 4 specimens. From mouth of bearded seal, *Erignathus barbatus,* August 31, 1948, 11 specimens. In 120 feet, September 15, 1948, 2 specimens. West shore of Elson Lagoon, September 19, 1948, 5 specimens. Washed ashore August 21 and 22, 1949, 4 specimens. Elson Lagoon, October 4, 1949, 27 specimens.

This variety of *Gammarus locusta* has been recorded from North and South Norway, Spitzbergen, Iceland, East Greenland, Barents Sea, Jan Mayen, and Arctic America. The largest specimen in the present collection, a male, measures 50 mm. This variety has been taken down to 40 m.

GAMMARACANTHUS LORICATUS (Sabine)

Gammaracanthus loricatus Stebbing, 1906, p. 508.—Stephensen, 1940a, p. 356, fig. 52, 1; 1944b, p. 115, fig. 10.

Material collected.—In shallow water, 300 feet from shore, July 20, 1948, 2 specimens. In 30 feet, Eluitkak Pass, Elson Lagoon, August 6, 1948, 6 specimens, and August 10, 1948, 3 specimens. Washed ashore August 21 to 25, 1949, 2 specimens, September 6, 1949, 3 specimens, and September 12, 1949, 2 specimens. In Eluitkak Pass, Elson Lagoon, September 21, 1949, 3 specimens. Washed ashore October 4, 1949, 2 specimens. In 40 feet in Eluitkak Pass, August 1, 1950, 1 specimen. From beach at Point Barrow base, September 28, 1950, 2 specimens.

Gammaracanthus loricatus is a circumploar species that dips down into the North Atlantic along the east coast of Greenland and Labrador, and in the Pacific along the coast of Alaska as far as Nushagak Bay. There are in the U. S. National Museum specimens from the southern end of Hudson Bay; Hudson Strait, Frobisher Bay, Baffin Land; Port Burwell and Rigolet, Labrador; and Collinson Point, Elson Lagoon, Point Barrow, Cape Smyth, Kotzebue Sound, Norton Sound, and Nushagak Bay, Alaska. The largest specimen, a female, in the present collection measures 58 mm. This species occurs from shallow water down to about 35 m.

WEYPRECHTIA PINGUIS (Kröyer)

Amathilla pinguis Buchholz, 1874, p. 353, pl. 9, fig. 2.

Weyprechtia pinguis Stebbing, 1906, p. 382.—Shoemaker, 1920, p. 21; 1926, p. 9.—Gurjanova, 1935a, p. 77.—Stephensen, 1940a, p. 297, fig. 34, 2; 1944b, p. 101.

Material collected.—Taken in Eluitkak Pass, Elson Lagoon, August 30, 1948, 1 specimen. Off Point Barrow base in 80 feet, September 9, 1948, 1 specimen. From beach at Point Barrow base, September 24, 1950, 1 specimen.

Weyprechtia pinguis is a circumpolar species that dips down into the cold North Atlantic. It has been recorded from Nova Zembla; Franz Joseph Land; White Sea; Spitzbergen; Murman coast; East and West Greenland; Baffin Bay; Hudson Strait and Hudson Bay; Bernard Harbor, Northwest Territory; and Okhotsk Sea.

There are specimens in the U.S. National Museum taken off Halifax, N. S. It reaches a length of 29 mm. and has been taken as low as 120 m.

WEYPRECHTIA HEUGLINI (Buchholz)

Weyprechtia heuglini STEBBING, 1894, p. 41, pl. 7; 1906, p. 381.—GURJANOVA, 1932, p. 168.—STEPHENSEN, 1940a, p. 296, fig. 34, 1.

Material collected.—In 8 to 10 feet, September 9, 1948, 3 specimens. In 80 feet, July 21 and September 9, 1948, 7 specimens. Washed ashore August 21, 1949, 1 specimen. In 37 feet, .75 mile out, June 23, 1950, 3 specimens (from baited screen trap through hole in ice).

Weyprechtia heuglini has been recorded from Nova Zembla, Kara Sea, Barents Sea, Spitzbergen, New Siberian Islands, north of Bering Strait, and Bering Sea or Okhotsk Sea (Derjavin, 1930, p. 328). There is a specimen in the U. S. National Museum from Bering Sea. This is a large species reaching a length of 51 mm. It has been recorded between 9 and 40 m.

MELITA DENTATA (Kröyer)

Gammarus dentatus KRÖYER, 1842, p. 159.
Gammarus subtener STIMPSON, 1864, p. 157.
Melita leonis MURDOCH, 1885b, p. 148, pl. 2, fig. 2.
Melita dentata SARS, 1894, p. 513, pl. 181, fig. 1.—STEBBING, 1906, p. 427.—STEPHENSEN, 1944b, p. 105.

Material collected.—In 120 to 150 feet, 4 to 5 miles out, September 9, 1948, 7 specimens. In 80 to 125 feet, September 15, 1948, 4 specimens. In 184 feet, 5 miles out, August 30, 1949, 1 specimen. Washed ashore September 22, 1949, 1 specimen. In 175 feet, October 14, 1949, 15 specimens. In 295 feet, 5 miles out, October 6, 1949, 6 specimens. In 341 feet, 6 miles out, October 11, 1949, 3 specimens. Washed ashore September 22, 1949, 1 specimen. In 175 feet, October 14, 1949, 15 specimens. In 162 feet, 3.2 miles out, February 18, 1950, 1 specimen.

Melita dentata is a circumpolar species that dips down into the colder waters of the North Atlantic and North Pacific. It is a large species, some of the specimens in the present collection reaching a length of 30 mm. In the U.S. National Museum there are no specimens taken south of Marthas Vineyard on the east coast of the United States. There is a published record of the occurrence of *M. dentata* at Cameron, La. I have examined these specimens and find that they are *Melita appendiculata* (Say) (1818, p. 377), of which *Melita fresnelii* (Audouin) is a synonym. On the west coast of America *Melita dentata* extends south at least to Corona Del Mar, Orange County, Calif. The description of *Gammarus subtener* Stimpson from Puget Sound agrees with *Melita dentata,* with the exception of the third uropods, which were missing. His specimen, which was not quite a quarter of an inch in length, was very immature. *Melita dentata* has been recorded from shallow water down to 113 m.

MELITA FORMOSA Murdoch

Melita formosa Murdoch, 1885b, p. 147, pl. 2, fig. 1.—Stebbing, 1906, p. 427.—Gurjanova, 1929b, p. 39; 1935a, p. 77.—Stephensen, 1940a, p. 309, fig. 37.
Melita goesii Hansen, 1887a, p. 146, pl. 5, fig. 8; 1887b, p. 228, pl. 21, fig. 13.

Material collected.—Washed ashore at Point Barrow base, August 21 to 25, 1949, 10 specimens; September 6, 1949, 30 specimens; September 19, 1949, 2 specimens; September 22, 1949, 8 specimens; August 23, 1950, about 50 specimens; September 24, 1950, 38 specimens; and September 28, 1950, 1 specimen.

Melita formosa has been recorded from Point Barrow, Alaska; North Norway; Spitzbergen; Murman Coast; Barents Sea; Nova Zembla; New Siberian Islands; Japan; and West Greenland.

Many fine specimens of this species were washed ashore at Point Barrow, the largest of which measure about 30 mm. It has been recorded from shallow water down to 480 m.

MELITA VALIDA, new species

Figure 15, *a-j*

Material collected.—Beach at Point Barrow, September 28, 1950, 2 specimens.

Male.—Head with broadly rounding lateral margin, and with a small notch on lower margin. Eye small and indistinct. Antenna 1 much longer than antenna 2, first joint stouter than, but equal in length to, the second, which is twice as long as the third; flagellum much longer than peduncle and composed of about 40 joints; acces-

sory flagellum of 3 long and 1 small terminal joint. Antenna 2 about as long as the head plus the first three or four body segments; third joint nearly half the length of the fourth, which is a little longer

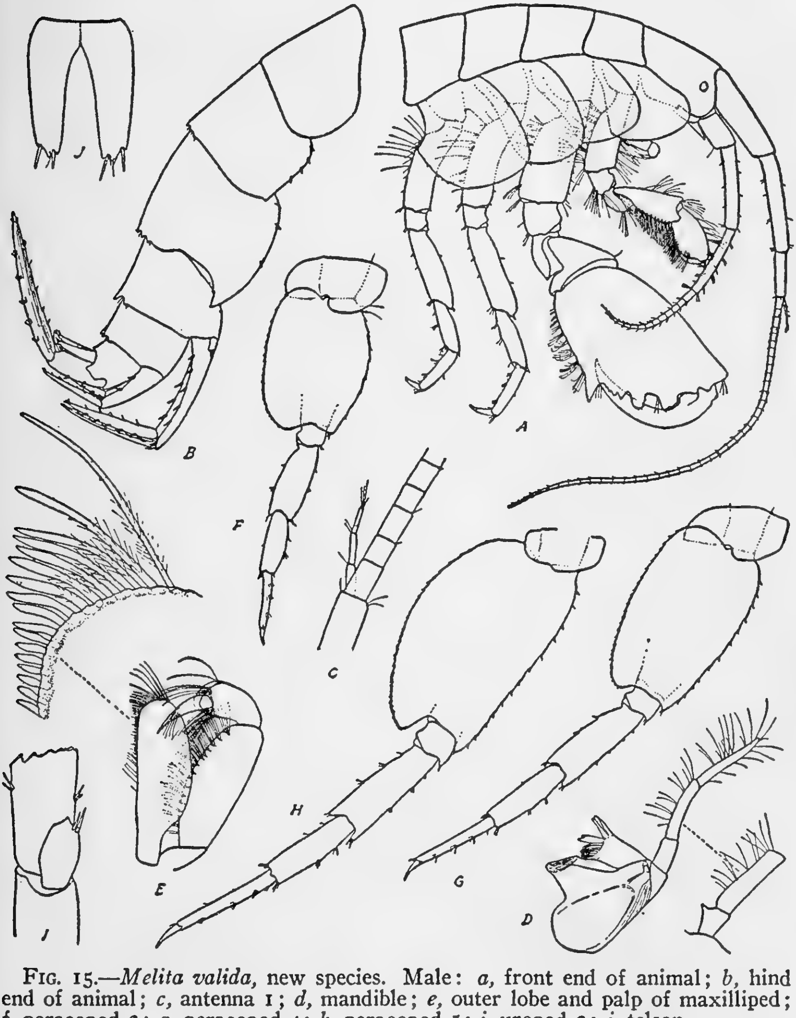

FIG. 15.—*Melita valida,* new species. Male: *a,* front end of animal; *b,* hind end of animal; *c,* antenna 1; *d,* mandible; *e,* outer lobe and palp of maxilliped; *f,* peraeopod 3; *g,* peraeopod 4; *h,* peraeopod 5; *i,* uropod 3; *j,* telson.

than the fifth; flagellum short and composed of about 14 joints; gland cone prominent.

Mandible with strong molar, which extends at its base into a prominent angular lobe; cutting edge narrow; accessory plate narrow with bifid apex; spine row of many spines; first joint of palp with a tooth

on its outer margin; third joint longer than the second. Maxilla 1 much as that figured by Sars for *M. palmata* (1894, pl. 179^{m1}); inner lobe long with narrow angular apex and the inner margin bearing a row of setae; outer lobe normal; first joint of palp with 3 groups of long slender spines on outer margin; second joint large, widening distally and with the broad, slightly convex distal margin bearing many slender spines. Maxilla 2 much as that figured by Sars for *M. palmata* (1894, pl. 179^{m2}), but inner and outer lobes are of equal width, with inner lobe being slightly shorter. Maxilliped, inner lobe reaching beyond middle of outer lobe and armed with the usual spines, but no teeth; outer lobe long, reaching about to the end of the second joint of palp, armed distally and on the inner margin with spines which become shorter toward the base.

Gnathopod 1, second joint a little longer than the fifth, which is longer than the sixth; all joints with many long setae; sixth joint with front and rear margins convex; palm oblique, convex, finely dentate throughout, armed throughout with closely set short spinules, and without defining angle or defining spines. Seventh joint fitting palm and provided on inner margin with very fine setae or spinules. Gnathopod 2 very large and robust; sixth joint about as long as the second to fifth joints combined; palm very oblique, armed with 2 large teeth, several small teeth, and a strong defining tooth. Seventh joint strong and curved with the distal end resting on the inside surface of the sixth joint when it is closed against the palm.

Peraeopods 1 and 2 alike but 1 slightly the longer. Peraeopods 3 to 5 increasing consecutively in length, second joint expanded, somewhat produced below posteriorly, and with hind margin very finely serrate. The mesosome segments and first metasome segment are without dorsal teeth. Metasome segment 2 has 5 dorsal teeth, and segment 3 has 5 dorsal teeth and a small tooth just above the lower posterior angle. Urosome segment 1 has 3 dorsal teeth; segment 2 has 4 dorsal teeth and segment 3 has a mere suggestion of 2 dorsal teeth. The uropods are shown in figure 15, *b* and *i*. The telson extends to about the end of the peduncle of uropod 3, and is cleft to its base with each lobe ending in a central triangular lobe, on either side of which is a spine. Length of male 28 mm.

Type.—A male, U.S.N.M. No. 93809, taken from beach at Point Barrow, Alaska, September 28, 1950, Ira L. Wiggins, collector.

Remarks.—In the smaller male the armature of the palm of gnathopod 2 is somewhat different from the larger male, the arrangement giving the impression of 3 major teeth.

MAERA DANAE (Stimpson)

Leptothoe danae STIMPSON, 1854, p. 46, pl. 3, fig. 32.
Moera danae BATE, 1862, p. 190, pl. 34, fig. 6.
Moera fusca BATE, 1864, p. 667.
Maera dubia CALMAN, 1898, p. 269, pl. 32, fig. 3.—HOLMES, 1904b, p. 239; 1908, p. 539.
Maera danae HOLMES, 1905, p. 525, pl. 12, fig. 2.—STEBBING, 1906, p. 440.—BLAKE, 1933, p. 252.

Material collected.—In 125 feet, 4 to 5 miles out, September 9, 1948, 4 specimens. In 110 feet, September 16, 1948, 3 specimens. Washed ashore at Point Barrow base, August 25, 1949, 1 specimen. In 328 feet, September 1, 1949, 6 specimens. In 217 feet, 7.5 miles out, September 6, 1949, 12 specimens. In 295 feet, 5 miles out, October 6, 1949, 6 specimens. In 175 feet, 4 miles out, October 14, 1949, 8 specimens. In 162 feet, 3.2 miles out, February 18, 1950, 4 specimens.

Leptothoe danae was described by Wm. Stimpson from Grand Manan in 1854, and he gave a very small, sketchy figure of the species. In 1862 C. Spence Bate transferred the species to the genus *Moera,* and gave a figure which is little better than Stimpson's. S. J. Holmes recorded it from Eastport, Maine, in 1905, and Charles H. Blake recorded it from Mount Desert Island, Maine, in 1933. There are specimens in the U. S. National Museum from the east coast of North America from Passamaquoddy Bay, New Brunswick; Casco Bay, Maine; off Cape Cod, Mass.; off Newport, R. I.; and Vineyard Sound.

C. Spence Bate in 1864 (p. 667) described *Moera fusca* from Esquimalt Harbor, Vancouver Island; and in 1898 W. T. Calman described *Maera dubia* from Puget Sound. *Moera fusca* and *Maera dubia* undoubtedly represent the same species, and both appear to be synonyms of *Maera danae.* Excellent specimens were taken off Point Barrow which agree specifically with specimens from the New England coast.

The largest specimens from the east coast of North America measure about 18 mm. The largest specimens from the west coast and Alaska are also about this size. In the U. S. National Museum there are specimens from the west coast of Queen Charlotte Islands; Puget Sound; and Monterey Bay, Calif.

Some specimens of *Maera danae* from the west coast differ somewhat from the typical east-coast form. The second joint of the third, fourth, and fifth peraeopods is occasionally wider in proportion to its length, and the rami of the third uropods are proportionately slightly shorter, but these variations do not appear to be of specific value.

Maera danae bears a rather close superficial resemblance to *Maera loveni* (Bruzelius), a much larger species, which inhabits the Arctic. In *M. loveni* the defining tooth of the palm of the second gnathopod of the male bears a long, slender spine, and the second joint of the third, fourth, and fifth peraeopods is long and narrow.

CERADOCUS TORELLI (Goës)

Ceradocus torelli Stebbing, 1906, p. 432.—Brüggen, 1909, p. 38, pl. 1, fig. 4.—Gurjanova, 1930, p. 244.—Stephensen, 1940a, p. 310, fig. 38; 1944a, p. 22; 1944b, p. 106.

Material collected.—Taken on the beach at Point Barrow base, Alaska, September 28, 1950, 3 specimens.

Ceradocus torelli, an arctic species, has been recorded from New Siberian Islands, Murman Coast, Iceland, East and West Greenland, and Bering or Okhotsk Sea. The present record is the first for Alaska.

In the U. S. National Museum there is a specimen of this species from North Devon Island, Arctic Canada; and one taken by the Fisheries steamer *Albatross* at station 5009 (46° 24′ 10″ N., 142° 40′ 00″ E.), September 24, 1906, in 25 fathoms. *Ceradocus torelli* is a very large species, the largest specimen in the present collection, a female, measuring 54 mm. It has been taken as low as 95 m.

ANISOGAMMARUS (EOGAMMARUS) MACGINITIEI, new species

Figure 16, *a-f*

Material collected.—From beach at Point Barrow base (71° 91′ N., 156° 41′ W.), September 28, 1950, 6 specimens.

Male.—Head not as long as the first two thoracic segments; lateral lobes truncate with rounding corners; eye small, oval, and black. Antenna 1 a little longer than antenna 2; first joint about as long as second and third combined; third not half the length of second; flagellum longer than peduncle and composed of about 24 joints; accessory flagellum of 4 or 5 joints. Antenna 2, gland cone of second joint large and prominent, third joint half as long as the fourth joint, which is longer than the fifth; flagellum shorter than peduncle and composed of about 18 joints. Gnathopods rather short and stout. Gnathopod 1 a little larger than gnathopod 2; second joint as long as the sixth joint; fifth joint about half as long as the sixth, and with a small lower lobe; sixth joint nearly as wide as long, palm transverse, slightly concave, armed on outer and inner margin with 4 short, blunt spine teeth, and defined by 2 spines; seventh joint stout, curved,

as long as palm and bearing a slight protuberance on the inner margin. Gnathopod 2 much like 1; second joint a little longer than sixth; fifth joint over half as long as sixth, and with the lower lobe wider than in gnathopod 1; sixth joint a little longer than wide; palm transverse and armed with spine teeth as in gnathopod 1; seventh joint as in gnathopod 1.

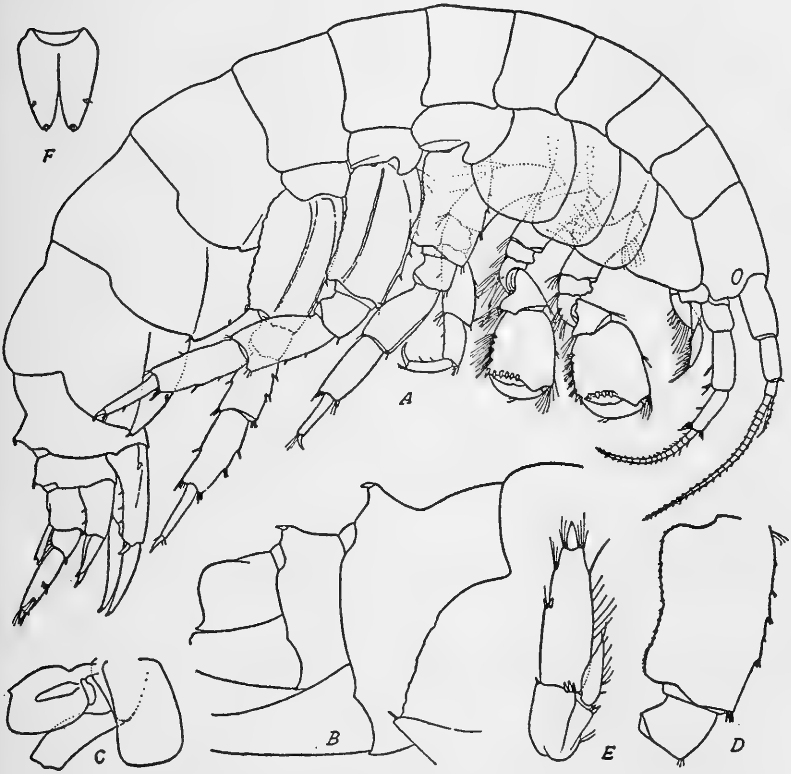

Fig. 16.—*Anisogammarus macginitiei*, new species. Male: *a*, entire animal; *b*, hind end of animal; *c*, gill of gnathopod 2; *d*, peraeopod 3; *e*, uropod 3; *f*, telson.

Peraeopods 1 and 2 alike, but 1 a little the longer. The proportions of peraeopod 1 as shown in figure 16, *a*. Peraeopod 3 longer than peraeopod 1; second joint not much expanded, with hind margin slightly concave and lower hind corner broadly rounding; fourth and fifth joints subequal in length and little expanded; sixth joint slender and shorter than fifth; seventh joint small. Peraeopod 4 longer than 3 and perhaps a little longer than 5; second joint with hind margin slightly concave and lower hind corner narrowly rounding; remaining

joints proportioned as in peraeopod 3. Peraeopod 5 with hind margin of second joint slightly convex; remaining joints as in peraeopod 4. Metasome segments as shown in figure 16, *a*. Urosome segment 1 bearing dorsally a single conical protuberance bearing a small backward-pointing apical spine. Urosome segment 2 bearing 2 transverse dorsal protuberances similar to the one on segment 1 but smaller.

Uropod 1 reaching back farther than uropod 2; peduncle longer than rami, armed on upper lateral margin with 3 small spines and on the outer distal corner with 1 stout upward-curving spine; rami without lateral spines, but bearing a single short apical spine. Uropod 2 similar to uropod 1, but shorter. Uropod 3 extending back farther than uropod 1, peduncle about half the length of the first joint of the outer ramus; outer ramus rather stout and broad, with a group of small spines near the middle of the outer margin, a group of setae near the end, and a row of setae on the inner margin; second joint very small; inner ramus nearly half the length of the outer ramus, inner margin and apex bearing a few setae.

The gill of gnathopod 2 and peraeopods 1, 2, and 3 bears 2 small sausage-shaped appendages; gill of peraeopod 4 bears 3 appendages and that of peraeopod 5 bears 1 appendage. Telson reaching beyond the end of peduncle of uropod 3, cleft nearly to its base, each lobe bearing 1 small lateral and a small apical spine. Length of male 37 mm.

Type.—A male, U.S.N.M. No. 92784, taken from beach at Point Barrow base, Alaska (71° 19′ N., 156° 41′ W.), September 28, 1950. Received from Naval Research Laboratory, U. S. Navy.

Female.—The female is like the male and is about the same size.

Family DEXAMINIDAE

GUERNEA NORDENSKIÖLDII (Hansen)

Prinassus nordenskiöldii HANSEN, 1887a, p. 82, pl. 2, fig. 7; pl. 3, fig. 1.—STEPHENSEN, 1913, p. 128.
Guernea nordenskiöldii STEBBING, 1906, p. 522.—SHOEMAKER, 1930b, p. 335.

Material collected.—In 125 feet, 4 to 5 miles out, September 9, 1948, 1 specimen. In 120 feet, September 15, 1948, 1 specimen. In 741 feet, 12.1 miles out, August 17, 1949, 1 specimen. In 184 feet, 5 miles out, August 30, 1949, 1 specimen. In 217 feet, 7.5 miles out, September 6, 1949, 1 specimen. In 341 feet, 6 miles out, October 11, 1949, 1 specimen. In 175 feet, 4 miles out, October 14, 1949, 2 specimens.

Guernea nordenskiöldii was described by H. J. Hansen from Davis Strait in 1887. In 1917, 9 specimens were taken in the Gulf of St.

Lawrence by the Cheticamp Expedition. In the U. S. National Museum there are 3 specimens from Woods Hole, Mass. The present records from Alaska extend the range of this small amphipod considerably to the west. It measures about 3.3 mm., and has been recorded between 28 and 113 m.

Family TALITRIDAE

HYALE, species

A single male *Hyale* was taken September 15, 1948, off Point Barrow, at a depth of 120 feet, and it appears to be the only representative of this genus ever taken on the northern coast of Alaska. *Hyale prevostii* Milne-Edwards was recorded from Murman Coast by K. M. Derjugin in 1915 (p. 451), and by E. Gurjanova in 1931 (p. 200), but these two identifications are undoubtedly incorrect, as *H. prevostii,* being a temperate-water species, does not occur in cold northern or arctic waters. The male taken off Point Barrow does not agree with any of the described species of *Hyale;* therefore, more material from Point Barrow will have to be studied before the status of this specimen can be determined.

Family AORIDAE

LEMBOS ARCTICUS (Hansen)

Microdeutopus arcticus HANSEN, 1887b, p. 231, pl. 22, fig. 3.
Lembos arcticus STEBBING, 1906, p. 595.—BRÜGGEN, 1909, p. 39, pl. 3, figs. 22-28. —DERJAVIN, 1930, p. 327.—GURJANOVA, 1935a, p. 77.—STEPHENSEN, 1942, p. 366, fig. 53.

Material collected.—Washed ashore September 9, 1948, 1 specimen ♀. In 162 feet, 3.2 miles out, February 18, 1950, 2 specimens ♂ and ♀.

This species has been taken in the Kara Sea, Barents Sea, Nova Zembla, Jugor Strait, Sea of Japan, and now from northern Alaska. It is a large species, measuring as much as 29 mm., and it has been taken as low as 100 m.

Family PHOTIDAE

PHOTIS REINHARDI Kröyer

Photis reinhardi SARS, 1894, p. 569, pl. 202.—STEBBING, 1906, p. 607.—STEPHENSEN, 1942, p. 369; 1944b, p. 117.—SHOEMAKER, 1945a, p. 3, fig. 1.

Material collected.—In 110 feet, September 9, 1948, 1 specimen. In 125 feet, September 9, 1948, 7 specimens. In 120 feet, Septem-

ber 15, 1948, 2 specimens. In 120 feet, August 8, 1949, 1 specimen. In 438 and 741 feet, 12.1 miles out, August 17, 1949, 2 specimens. In 184 feet, 5 miles out, August 30, 1949, 1 specimen. In 216 feet, 4.3 miles out, October 6, 1949, 1 specimen. In 295 feet, 5 miles out, October 6, 1949, 2 specimens. In 341 feet, 8 miles out, October 11, 1949, 1 specimen. In 453 feet, 8 miles out, October 11, 1949, 25 specimens. In 175 feet, 4 miles out, October 14, 1949, 4 specimens. In 162 feet, 3.2 miles out, February 18, 1950, 7 specimens.

Photis reinhardi is probably a circumpolar species that extends down into the North Atlantic and North Pacific. It has been recorded from the coasts of northern Europe, Iceland, East and West Greenland, Labrador, Gulf of St. Lawrence, east coast of the United States as far south as the Gulf of Mexico, and in the Pacific from the Sea of Okhotsk. It reaches a length of 5 mm., and has been recorded from shallow water down to about 94 m.

EURYSTHEUS MELANOPS Sars

Figure 17, *a-d*

Gammaropsis melanops SARS, 1894, p. 560, pl. 199, fig. 1, ♀.
Eurystheus maculatus STEBBING, 1906, p. 617.
Eurystheus melanops STEPHENSEN, 1942, p. 370.

Material collected.—In 125 feet, 5 to 12.1 miles out, September 8 to 23, 1948, 29 specimens. In 152 to 741 feet, 4 to 16 miles out. August 17 to October 14, 1949, 50 specimens.

As the second gnathopod of the male appears to be quite variable, figures of the gnathopods of a male measuring 8 mm. taken at Point Barrow are given here. A figure of the long, slender epistome, which is characteristic of this species, is also given. *Eurystheus melanops* has been recorded from Murman Coast, White Sea, Nova Zembla, Iceland, East and West Greenland, Gulf of St. Lawrence, Norway, and Denmark. In the U. S. National Museum there are specimens from Eastport, Maine, taken in 1893. It reaches a length of about 12 mm., and has been recorded as low as 100 m.

PROTOMEDEIA FASCIATA Kröyer

Figure 17, *e-f*

Protomedeia fasciata SARS, 1894, p. 552, pl. 196.—STEBBING, 1906, p. 623.—STEPHENSEN, 1942, p. 376, fig. 56.

Material collected.—In 110 feet, September 8, 1948, about 60 specimens. Washed ashore August 21, 1949, 1 specimen. In 217 feet, 7.5 miles out, September 6, 1949, 2 specimens.

The male here figured, measuring about 8 mm., is as figured by Stephensen (1942, p. 376, fig. 56). The distal lobe at the lower hind margin of the second joint of the first gnathopod of the male is very characteristic of this species.

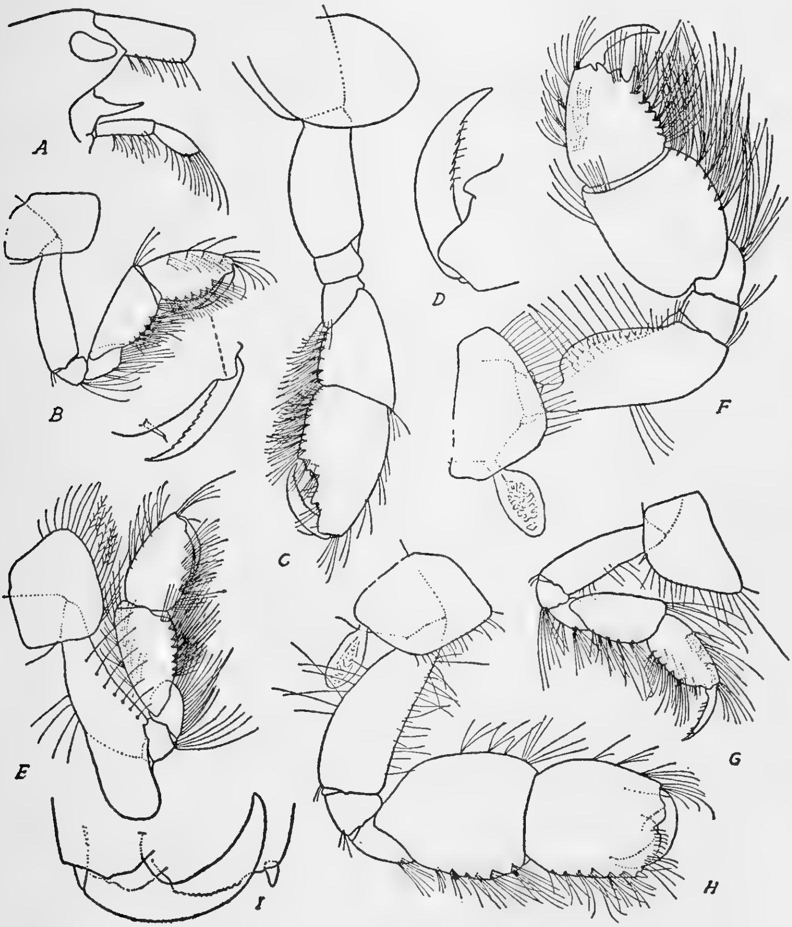

FIG. 17.—*a-d, Eurystheus melanops* Sars. Male: *a,* head, showing epistome; *b,* gnathopod 1; *c,* gnathopod 2; *d,* seventh joint of gnathopod 2. *e, f, Protomedeia fasciata* Kröyer. Male: *e,* gnathopod 1; *f,* gnathopod 2. *g-i, Protomedeia grandimana* Brüggen. Male: *g,* gnathopod 1; *h,* gnathopod 2; *i,* end of sixth joint gnathopod 2, showing the overlapping seventh joint.

Protomedeia fasciata has been recorded from Kara Sea; White Sea; Murman Coast; North, West, and South Norway; Kattegat and Skagerrak; east coast of England; Shetland Islands; Faröe Island; Iceland; Gulf of St. Lawrence; Woods Hole, Mass.; Greenland;

Dolphin and Union Strait; Kotzebue Sound, Alaska; and Spitzbergen. The present specimens are the first from the north coast of Alaska. This species measures about 8 mm., and it has been taken from shallow water down to about 87 m.

PROTOMEDEIA GRANDIMANA Brüggen

Figure 17, *g-i*

Protomedeia grandimana Brüggen, 1905, p. 223, pl., fig. 5; 1907, p. 233, figs. 8, 9.—Stebbing, 1906, p. 738.—Stephensen, 1942, p. 379 (part), fig. 57; 1944b, p. 122.

Material collected.—In 110 feet, September 8, 1948, 3 specimens.

The males taken at Point Barrow agree with a male 9 mm. in length identified by Brüggen, which is now in the collection of the U. S. National Museum. The figures here given of an Alaskan male agree with the specimen identified by Brüggen. Gnathopod 1 has no lobe at the lower hind margin of the second joint; the fifth joint is about as wide as, but a little longer than, the sixth; sixth joint with short convex palm which merges into the hind margin of joint without defining angle; seventh joint slender, slightly curved, and much longer than the palm. Gnathopod 2 much like Brüggen's figure; fifth joint a little wider and longer than sixth; sixth joint has palm nearly transverse, with a raised, finely serrate central ridge, palm defined by a rounding angle bearing a stout spine; seventh joint strong, greatly curved, and closing against the inside surface of sixth joint. This species reaches a length of 9 mm., and has been taken from shallow water down to 160 m.

Protomedeia grandimana has been recorded from Murman Coast, Kara Sea, Spitzbergen, and now from Alaska. Many of the localities assigned to this species by Stephensen (1942, pp. 384 and 385) undoubtedly apply only to the following species, *Protomedeia stephenseni.*

PROTOMEDEIA STEPHENSENI, new species

Figure 18, *a-l*

Protomedeia grandimana Stephensen, 1942, p. 379 (part), figs. 58, 59.

Material collected.—Washed ashore at Point Barrow base, Alaska, August 21, 1949, 10 specimens. Washed ashore at Point Barrow base, Alaska, September 22, 1949, 1 specimen.

Stephensen (1942, p. 379, figs. 58 and 59) partially described and figured a male and female specimen of *Protomedeia* which he identified as *P. grandimana* Brüggen. His specimens, taken at East Iceland

and North Norway, are undoubtedly the same as the present specimens taken at Point Barrow, Alaska. Mature specimens of this species and mature specimens of *P. grandimana,* both taken at Point

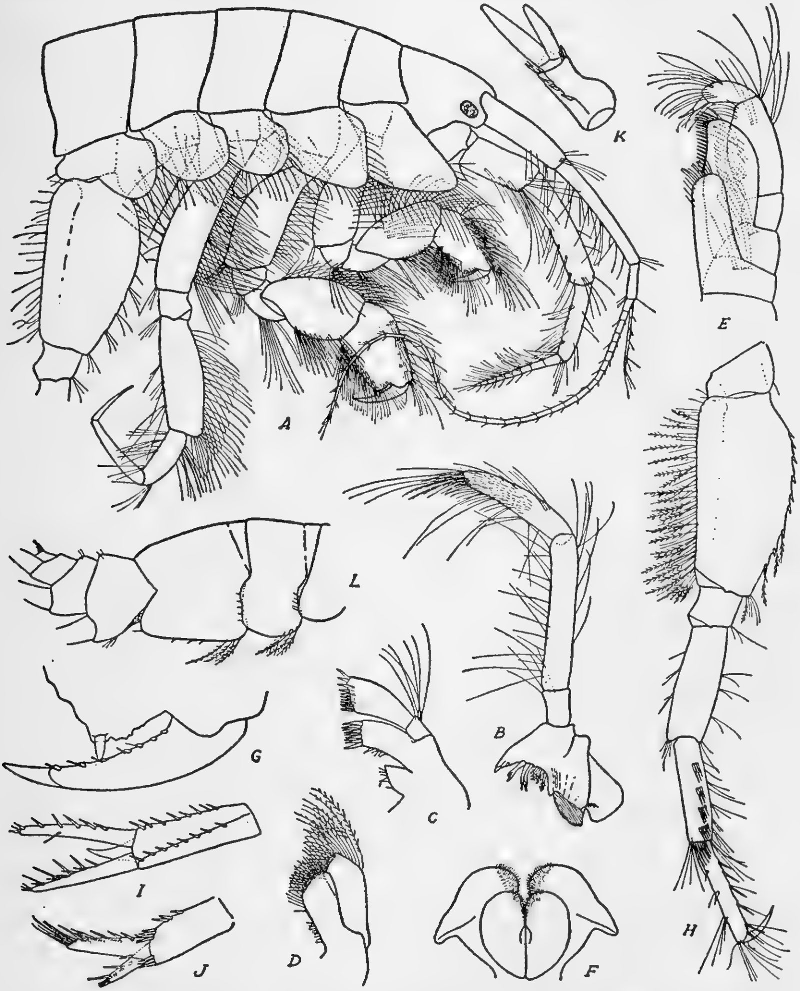

FIG. 18.—*Protomedeia stephenseni,* new species. Male: *a,* front end of animal; *b,* mandible; *c,* maxilla 1; *d,* maxilla 2; *e,* maxilliped; *f,* lower lip; *g,* palm and seventh joint of gnathopod 2; *h,* peraeopod 4; *i,* uropod 1; *j,* uropod 3, side view; *k,* uropod 3, top view; *l,* hind end of animal.

Barrow, present characters which definitely separate these two species. I am, therefore, naming this new species in honor of the late Dr. K. Stephensen.

Male.—Head about as long as the first two body segments com-

bined; lateral lobes rather prominent; eye small and dark. Antenna 1 considerably longer than antenna 2; first peduncular joint shorter than second; third joint about one-third as long as second; flagellum longer than peduncle and composed of about 30 joints; accessory flagellum of 7 joints. Antenna 2, third peduncular joint about two-thirds as long as fourth, which is about one-third longer than the fifth; flagellum a little longer than the fifth peduncular joint and composed of about 9 joints.

Mandible, cutting edge narrow; accessory plate bearing distal teeth; 2 teeth in spine row followed by a few plumose setules; molar strong with its base produced into a blunt process; palp long, third joint about three-fourths as long as the second, very setose, and armed distally with many long and short spines, a few of the short ones being pectinate. Lower lip with large inner lobes and short blunt mandibular processes. Maxilla 1, inner plate short with only a few marginal setules; outer plate armed with 10 or 11 spine teeth; palp large, expanded distally, its obliquely truncate end armed on the inside with 11 spines and on the outside with 12. Maxilla 2, outer plate longer than inner, both expanded distally and armed with long and short spinules. Maxilliped, inner lobe reaching to middle of outer lobe and armed on the rounding distal end with a few slender spines but no spine teeth; outer lobe reaching nearly to end of second joint of palp, inner margin armed with slender spine teeth; palp with second joint expanded in the middle; third joint short; fourth joint small and slender and bearing a sharp slender nail.

Gnathopod 1, fifth joint a little longer and wider than sixth; sixth joint with short transverse palm which is greatly overlapped by the seventh joint. Gnathopod 2 longer and stouter than 1; fifth joint longer and wider than sixth; sixth joint with short transverse palm defined by a stout spine; seventh joint considerably overlapping palm and armed on inner margin with a few short spinules and setules. Both gnathopods very setose or hairy. Peraeopods 1 and 2 subequal in length with proportions as shown by figure 18, *a*. Peraeopods 3 to 5 much alike and increasing consecutively in length. The armature of peraeopods 3 to 5 as shown for peraeopods 4 (fig. 18, *h*).

Lower posterior margin of metasome segment 3 evenly and bluntly rounding (fig. 18, *l*). Uropods 1 and 2 extending back the same distance and both armed with long slender spines. Uropod 3 extending back a little farther than uropod 2; outer ramus longer than inner, both rami bearing rows of long slender spines, and outer ramus carrying also a group of long apical spines which are characteristic of this species; the peduncle when viewed from above shows an inner

proximal lobe (fig. 18, *k*). Coxal plates overlapping slightly; first plate produced considerably forward below, and all plates furnished with long marginal setae. Length of fully grown male about 14 mm.

Female.—The female is like the male except that the gnathopods are a little smaller and weaker. Mature females are as large as the males.

Type.—A male, U.S.N.M. No. 92257, washed ashore at Point Barrow base, Alaska, August 21, 1949, collected by Geo. E. MacGinitie.

Beside the Alaskan specimens there are in the U. S. National Museum a specimen of this species taken at Nain, Labrador, August 1908; and one at Port Burwell, Labrador, October 1927.

Protomedeia stephenseni has been taken at Spitzbergen, North Norway, Iceland, East and West Greenland. Many of the localities assigned to this species by Stephensen (1942, pp. 384 and 385) undoubtedly belong only to *P. grandimana.*

Remarks.—The female of *P. stephenseni* can be distinguished from *P. fasciata* by the group of long terminal setae on the outer ramus of the third uropod, the latter species having only one long seta and several short terminal spines. *P. grandimana* has a few long terminal setae, but not a conspicuous brush as in *P. stephenseni.*

PODOCEROPSIS LINDAHLII Hansen

Figure 19, *a-g*

Podoceropsis lindahlii HANSEN, 1887a, p. 157, pl. 6, fig. 2.—STEBBING, 1906, p. 619.

Material collected.—In 135 feet of water, 3.1 miles out, March 9, 1950, 1 specimen.

The specimen described and figured by Hansen appears to have been a female. As this species has not been taken since its discovery in 1887, the single specimen, a male, taken at Point Barrow, is here described and figured.

Male.—Head about as long as the first two body segments combined; lateral lobes produced considerably forward; eye oval and situated in the front of the lateral lobe. Antenna 1 a little over two-thirds as long as antenna 2, which is about one-half as long as the body. Antenna 1, first joint two-thirds as long as the second, and equal in length to the third; second joint one-third longer than third joint; flagellum about two-thirds as long as the peduncle and consisting of about 12 joints. Antenna 2, third joint a little over one-third the length of the fourth, which is equal in length to the fifth; flagellum not quite as long as the fifth peduncular joint, and consisting of about 7 joints, the first of which is the longest.

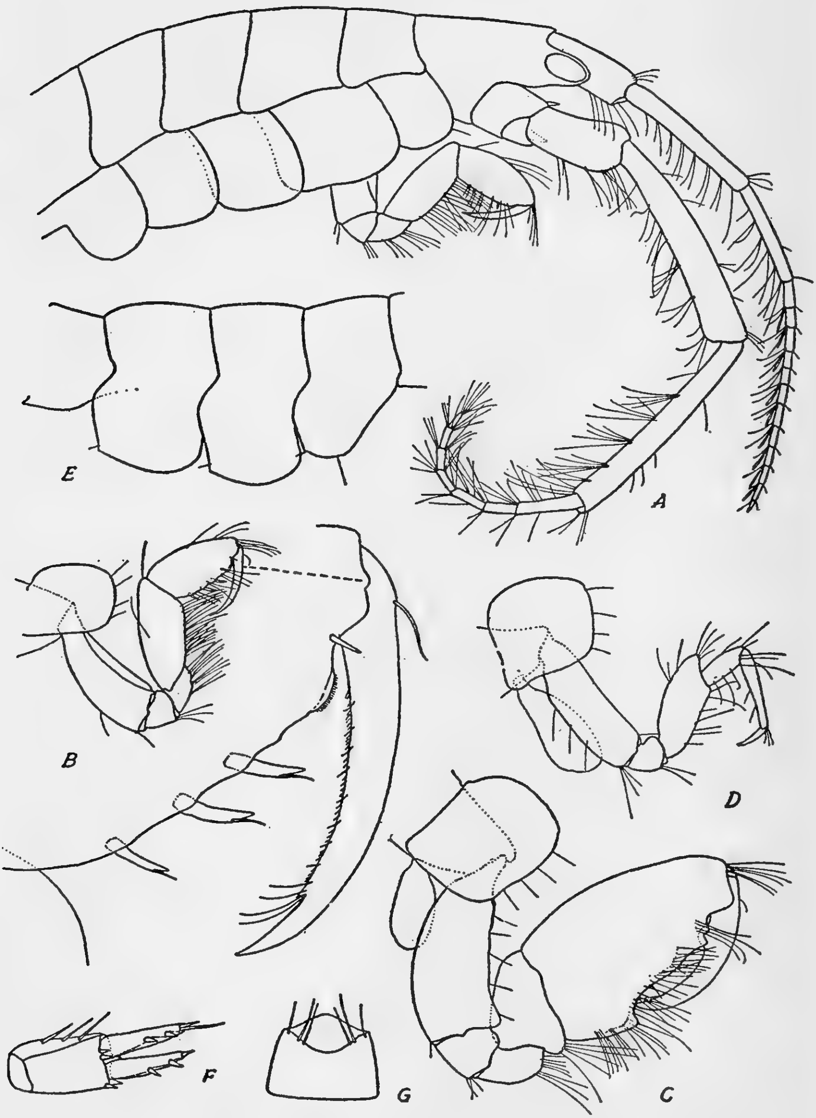

FIG. 19.—*Podoceropsis lindahlii* Hansen. Male: *a,* front end of animal; *b,* gnathopod 1; *c,* gnathopod 2; *d,* peraeopod 2; *e,* hind end of animal; *f,* uropod 3; *g,* telson.

Gnathopod 1 slender; second and fifth joints equal in length; sixth joint a little shorter than the fifth, but equal to it in width; palm very short and oblique and defined by a very thin lamella bearing very fine marginal teeth; hind margin of joint bearing 3 stout spines and several long slender spines; seventh joint reaching down beyond the middle of hind margin of the sixth joint, and armed on the inner margin with very fine teeth and a number of setules. Gnathopod 2 much larger and stronger than 1; second joint short and broad and slightly produced at the lower front corner; fifth joint shorter than wide; sixth joint strongly developed and one-third longer than wide; palm very oblique and nearly twice as long as the hind margin of the joint, a protuberance bearing a notch near the hinge, rest of palm sinuous, and concave near the defining angle; the defining angle and the adjacent border of the hind margin produced into a thin lamella which projects inward toward the axis of the body; seventh joint strongly curved, with the apex resting on the inside of palm near the defining angle, and bearing a prominent knob which rests on the inner surface of the protuberance of the palm when the joint is closed against the palm.

Peraeopods 1 and 2 alike, fourth joint expanded; fifth joint a little over half the length of the sixth; both fifth and sixth joints slender; seventh joint slender and not quite half the length of the sixth. Peraeopods 3 to 5 missing. Metasome segments with the lower lateral hind margin bulging considerably backward, and with the lower hind angle obtuse. The first and second urosome segments with a seta on either side of the posterior dorsal margin.

Coxal plate 1 the narrowest and 2 the broadest. Uropods 1 and 2 extending back about the same distance, with the outer ramus a little shorter than the inner. Uropod 1, peduncle armed on upper outer margin with about 9 short spinules, and with the lower distal end produced into a stout upward-curving tooth or projection. Uropod 2, peduncle with 1 or 2 spinules on upper outer margin, and without a tooth or projection on the lower distal end. Uropod 3 not reaching back quite as far as 2; rami of nearly equal length and as long as their peduncle. Telson not reaching to end of peduncle of uropod 3, wider than long and bearing a few posterior setae. The length of the male, 7 mm. Stebbing gives 91 m. for the depth of this species.

Family JASSIDAE

ISCHYROCERUS LATIPES Kröyer

Ischyrocerus latipes Kröyer, 1842, p. 162.—Stephensen, 1913, p. 212; 1944b, p. 124.—Schellenberg, 1924, p. 210, fig. 10; 1935, p. 29.—Gurjanova, 1935a, p. 77.

Podocerus latipes Boeck, 1876, p. 600, pl. 29, fig. 1.—Hansen, 1887a, p. 161, pl. 6, fig. 3.
Podocerus assimilis Sars, 1885, p. 205, pl. 17, fig. 1.
Ischyrocerus assimilis + latipes Stebbing, 1906, pp. 659, 660.
Ischyrocerus assimilis Stephensen, 1944a, p. 31, figs. 22, 23.

Material collected.—In depths from the beach down to 520 feet, between July 21, 1948, to July 29, 1951, about 300 specimens.

There are reasons that lead one to believe that *Ischyrocerus latipes* Kröyer and *Podocerus assimilis* Sars are one and the same species. Kröyer did not give the length of *I. latipes,* but Stebbing gives the length as 14 to 15 mm. *Podocerus assimilis* was described from a small specimen of 8 mm. The discrepancies in the descriptions of these two species could be due to the immaturity of *Podocerus assimilis.* Sars shows the lower hind corner of the third metasome segment as evenly and broadly rounding, which may have been due to the difficulty of observing the outline of the colorless transparent segment. In larger, more-mature specimens, this angle is quadrate or even slightly produced. He figures the first and second uropods as having very few spinules, which is correct for small specimens where the spinules are few and difficult to observe. The number of spinules on the uropods increases considerably with the size of the animal. In the specimen of *assimilis* measuring 9 mm., figured by Stephensen (1944a, p. 31, fig. 22u), there are 10 spinules on the outer margins of the outer ramus of the first uropod, while in specimens from Point Barrow measuring 16 mm. there are at least twice that number. The specimens from Point Barrow that have been identified as *Ischyrocerus latipes* agree with the figures given by Stephensen for *Ischyrocerus assimilis.* Little can be learned from Boeck's figure (1876, pl. 29, fig. 1) which, if it is of *I. latipes,* does not agree in some characters with that species. The specimens from Point Barrow and Stephensen's figure of *I. assimilis* agree with the figures given by Hansen (1887a, pl. 6, fig. 3) of *Podocerus latipes* as far as they go.

This species was correctly placed in the genus *Ischyrocerus* by Kröyer. Later authors placed it in *Podocerus,* and Stebbing in 1906 returned it to *Ischyrocerus.*

Ischyrocerus latipes has been recorded from Spitzbergen, White Sea, Kara Sea, Barents Sea, Jugor Strait, New Siberian Islands, East and West Greenland, and now for the first time from Alaska, where it appears to be quite common. This is a large species, reaching a length of 15 mm. or more. It has been taken down to 350 m.

The specimens from Hudson Bay identified as *I. assimilis* (Shoemaker, 1926, p. 10) have been examined and have been found to be *Ischyrocerus latipes* Kröyer.

ISCHYROCERUS COMMENSALIS Chevreux

Ischyrocerus commensalis Chevreux, 1900, p. 104, pl. 12, fig. 2.—Stebbing, 1906, p. 739.—Shoemaker, 1930b, p. 344, fig. 51.—Gurjanova, 1935b, p. 558. —Stephensen, 1944a, p. 28.

Material collected.—In 80 feet, July 21, 1948, 3 specimens. In 125 feet, 4 to 5 miles out, September 9, 1948, 16 specimens. In 120 feet, September 15, 1948, 5 specimens. In 420 feet, 7 miles out, August 9, 1949, 1 specimen. In 184 feet, 5 miles out, August 20, 1949, 7 specimens. In 217 feet, 7.5 miles out, September 6, 1949, 9 specimens. In 453 feet, 8 miles out, October 11, 1950, 1 specimen. Dredged in 6 to 50 m., July 29, 1951, 1 specimen.

Ischyrocerus commensalis was described by Édouard Chevreux from off Newfoundland in 1900. It was recorded from the Gulf of St. Lawrence in 1930. Gurjanova recorded it from Jugor Strait in 1935; and in 1944 Stephensen recorded it from West Greenland. The present records are the first for Alaska. Numerous specimens of this species were taken in Pavlof Bay, Alaska Peninsula, in 1940, by Dr. Waldo L. Schmitt while on the Alaska king crab investigation.

This species measures about 6 mm., and has been taken as deep as 682 m.

Family COROPHIIDAE

UNCIOLA LEUCOPIS (Kröyer)

Unciola leucopis Sars, 1894, p. 620, pl. 222.—Stebbing, 1906, p. 678.—Gurjanova, 1935a, p. 78.—Stephensen, 1942, p. 405; 1944b, p. 129.—Shoemaker, 1945b, p. 451, fig. 3.

Material collected.—In 80 feet, September 9, 1948, 1 specimen. In 438 feet, 12.1 miles out, August 17, 1949, 1 specimen. In 477 feet, 16 miles out, September 6, 1949, 3 specimens. In 218 feet, 4.3 miles out, October 6, 1949, 7 specimens. In 295 feet, 5 miles out, October 6, 1949, 4 specimens. In 341 feet, 6 miles out, October 11, 1949, 1 specimen. In 453 feet, 8 miles out, October 11, 1949, 4 specimens. In 152 feet, 3.5 miles out, October 14, 1949, 1 specimen. In 162 feet, 3.2 miles out, February 18, 1950, 2 specimens. Dredged at 38 m., July 29, 1951, near Point Barrow, 1 specimen.

Unciola leucopis has been recorded from Nova Zembla, Spitzbergen, west coast of Norway, Iceland, east and west coasts of Greenland, and along the east coast of North America down to Georges Bank off the coast of Massachusetts. The present records are the first for Alaska. This species reaches a length of 15 mm., and has been taken as deep as 1,260 m.

ERICTHONIUS HUNTERI (Bate)

Cerapus hunteri BATE, 1862, p. 264, pl. 45, fig. 3.
Ericthonius hunteri SARS, 1894, p. 605, pl. 216, fig. 2.—STEBBING, 1906, p. 673.—CHEVREUX and FAGE, 1925, p. 354, fig. 363.—STEPHENSEN, 1942, p. 403.

Material collected.—In 125 feet, 4 to 5 miles out, September 9, 1948, about 30 specimens. In 125 feet, September 15, 1948, 1 specimen. In 216 feet, 4.3 miles out, October 6, 1949, 3 specimens. In 152 feet, 3.5 miles out, October 14, 1949, 4 specimens. In 175 feet, 4 miles out, October 14, 1949, 15 specimens. In 162 feet, 3.2 miles from beacon light, February 18, 1950, 15 specimens.

Stephensen gives the following distribution: "West coast of Norway; Murman Coast; White Sea; northern Russia; Barents Sea; Jugor Strait; Bay of Biscay; Faroes; Black Sea; and Okhotsk Sea." The present records are the first for Alaska. *Ericthonius hunteri* reaches a length of 15 mm., and has been recorded down to 235 m.

ERICTHONIUS TOLLI Brüggen

Ericthonius tolli BRÜGGEN, 1909, p. 41, pl. 1, fig. 6, pl. 3, figs. 29-34.—SHOEMAKER, 1926, p. 10.—STEPHENSEN, 1933, p. 50.—GURJANOVA, 1938, pp. 374, 404.

Material collected.—In 125 feet, 4 to 5 miles out, September 9, 1948, 50 specimens. In 130 feet, 4 miles out, August 9, 1949, 2 specimens. In 420 feet, 7 miles out, August 9, 1949, 6 specimens. In 180 feet, 5 miles out, August 30, 1949, 15 specimens. In 217 feet, 7.5 miles out, September 6, 1949, 17 specimens. In 477 feet, 16 miles out, September 6, 1949, 3 specimens. In 130 feet, 6 miles out, September 15, 1949, 7 specimens. In 216 feet, 4.3 miles out, October 6, 1949, 4 specimens. In 341 feet, 6 miles out, October 11, 1949, 30 specimens. In 453 feet, 8 miles out, October 11, 1949, 20 specimens. In 152 feet, 3.5 miles out, October 14, 1949, 1 specimen. In 175 feet, 4 miles out, October 14, 1949, 8 specimens. Dredged at 6 to 50 m., July 29, 1951, 75 specimens.

Ericthonius tolli was described by Brüggen in 1909 from off Siberia (76° 37′ N., 147° 27′ E.) from a depth of 42 m. In 1926 it was recorded from Hudson Bay. Stephensen recorded it in 1933 from West Greenland (76° 40′ N., 76° 20′ W.), taken in 85 m. It was recorded from Japan in 1930 by Derjavin, and in 1938 by Gurjanova. The present records are the first for Alaska. There are in the U. S. National Museum a considerable number of specimens taken by the Fisheries steamer *Albatross* in Bering Sea in 1890. This species reaches a length of 13 mm., and it has been taken as deep as 235 m.

Family PODOCERIDAE

DULICHIA SPINOSISSIMA Kröyer

Dulichia spinosissima Sars, 1894, p. 635, pl. 228.—Stebbing, 1906, p. 709.—Stephensen, 1942, p. 416.

Material collected.—Washed ashore September 12, 1949, 1 specimen. Washed ashore October 3, 1949, 1 specimen. Washed ashore October 28, 1949, 1 specimen. In 162 feet, February 18, 1950, 1 specimen. In 80 feet, March 13, 1950, 1 specimen. From beach at Point Barrow, September 24, 1950, 2 specimens.

Dulichia spinosissima is a large circumpolar species that has not heretofore been recorded from Alaska. It reaches a length of 31 mm., and has been taken as deep as 100 m.

DULICHIA PORRECTA (Bate)

Dyopedos porrectus Bate, 1857, p. 151.
Dulichia porrecta Stebbing, 1906, p. 712.—Sars, 1894, p. 637. pl. 229.—Stephensen, 1942, p. 419.

Material collected.—In 80 feet, August 21, 1948, 9 specimens. In 213 feet, October 6, 1949, 1 specimen. In 175 feet, October 14, 1949, 1 specimen.

Dulichia porrecta has been recorded from Norway; Denmark; northwestern France; Shetlands; Iceland; West Greenland; Hudson Bay; Cape Smyth and Point Barrow, Alaska; and Northwest Pacific. It measures about 6 mm., and has been taken down to 118 m.

DULICHIA ARCTICA Murdoch

Figure 20

Dulichia arctica Murdoch, 1885a, p. 521; 1885b, p. 149, pl. 2, fig. 3.—Stebbing, 1906, p. 710.

Material collected.—In 184 feet, 5 miles out, August 30, 1949, 1 specimen. Washed ashore at Point Barrow base, September 12, 1949, 1 specimen. From the beach at Point Barrow, September 28, 1950, 4 specimens.

John Murdoch described this species from Point Barrow and Cape Smyth, Alaska, in 1885. In 1930 it was recorded from the Gulf of St. Lawrence from specimens taken by the Cheticamp Expedition. In the U. S. National Museum there is a male taken at Egg Harbor, Labrador, by Owen Bryant, August 10, 1908.

Murdoch's description being very brief and his figure lacking nearly all detail, a figure of a male 20 mm. in length, and a short diagnosis of the principal characters are given here.

The eye, which is reddish brown in alcohol, is situated in an oval, bulging area. The mesosome segments (with the exception of the seventh) bear on the lower margin an angular projection. The first coxal plate is produced into a long, narrow, pointed process. The second coxal plate bears a pointed process at the lower front and hind corner and a round knob in the middle. The third to seventh coxal plates bear a pointed or angular process on the lower margin. Gnathopod 1, sixth joint with a very short, nearly transverse palm. Gnathopod 2, second joint with the lower front corner produced into an angular process; sixth joint bearing 2 sharp angular processes; and

FIG. 20.—*Dulichia arctica* Murdoch. Male. Entire animal.

seventh joint bearing on its lower margin a prominent tooth or tubercle near the hinge and a lower, broader tubercle toward the apex.

Peraeopods 1 and 2 short and slender; second joint very little expanded. Peraeopods 3 to 5 rather short with second joint scarcely at all expanded. Peraeopod 5 longer than 3 or 4. The coalesced first and second urosome segments shorter than uropod 1.

The figure given by Murdoch was of a smaller male, which did not possess fully developed characters. *Dulichia arctica* reaches a length of at least 20 mm., and it has been taken as low as 75 m.

PARADULICHIA, species

Material collected.—Washed ashore at Point Barrow base, August 21, 1949, 1 specimen. Beach at Point Barrow base, September 28, 1950, No. 528, 1 specimen.

These 2 male specimens, measuring about 9 mm. each, are not in a sufficiently good state of preservation for describing or figuring.

Suborder HYPERIIDEA

Family HYPERIIDAE

HYPERIA MEDUSARUM (Müller)

Hyperia medusarum Bovallius, 1889, p. 147, pl. 9, figs. 1-21.—Sars, 1890, p. 7, pl. 3, fig. 2.—Stephensen, 1923, p. 15; 1924, p. 80; 1933, p. 61; 1940b, p. 4.

Material collected.—From medusa taken halfway between Point Barrow and Point Barrow base, August 10, 1948, 1 specimen. Washed ashore near Point Barrow base July 20-23, 1949, 8 specimens; August 21, 1949, 1 specimen; September 22, 1949, 2 specimens; September 28, 1949, 1 specimen; October 1-5, 1949, 8 specimens; November 19, 1949, 2 specimens. In fish trap, February 20, 1950, 1 specimen. Washed ashore at Point Barrow base, July 19, 1950, 87 specimens. Beach at Point Barrow base, September 28, 1950, 5 specimens.

Hyperia medusarum occurs in the North Atlantic and North Pacific, and there are a few records from the Arctic. It has been recorded from Hudson Bay (Shoemaker, 1926, p. 3) and from Point Barrow by John Murdoch in 1885. It reaches a length of 15 mm., and has been taken as low as 250 m.

HYPERIA GALBA (Montagu)

Hyperia galba Sars, 1890, p. 7, pl. 2, pl. 3, fig. 1.—Calman, 1898, p. 265.—Walker, 1904, p. 235.—Stephensen, 1923, p. 17; 1944b, p. 9.—Barnard, 1930, p. 411; 1932, p. 273.

Material collected.—In 80 feet, 1.8 miles out, March 20, 1950, 6 specimens.

Dr. Stephensen says of this species: "Very widely distributed in the northern Atlantic, mainly north of 50° N., and arctic seas; probably circumpolar." Barnard (1930, p. 411) records it west of the Falkland Islands, and from Melbourne Harbor, Australia, and later (1932, p. 273) from South Africa. This species reaches a length of about 24 mm., and has been taken as low as 2,000 m.

HYPEROCHE MEDUSARUM (Kröyer)

Hyperoche kroeyeri Sars, 1890, p. 9, pl. 4.—Shoemaker, 1920, p. 24.
Hyperoche medusarum Stephensen, 1923, p. 13; 1933, p. 61; 1940b, p. 5.—Barnard, 1932, p. 276.—Crawford, 1936, p. 105.

Material collected.—In plankton off Point Barrow base, August 16, 1948, 1 specimen.

Stephensen says of this species: "A boreo-arctic species, widely distributed in the northern Atlantic with adjacent arctic seas." It

has been recorded from Collinson Point, Alaska (*H. kroeyeri* Shoemaker, 1920, p. 24); and from the Gulf of St. Lawrence (Shoemaker 1930b, p. 350). It ranges in length from 8 to 20 mm., and has been taken between 200 and 1800 m.

THEMISTO LIBELLULA (Mandt)

Themisto libellula Buchholz, 1874, p. 385, pl. 15, fig. 1.—Sars, 1890, p. 13, pl. 6, fig. 1.—Stephensen, 1923, p. 24; 1933, p. 63; 1944b, p. 12.

Material collected.—In 125 feet, 4 to 5 miles out, September 9, 1948, 3 specimens. Off Point Barrow base in plankton, July 26, 1948, 2 specimens. Washed ashore September 6, 1949, 1 specimen; and September 12, 1949, about 1,000 specimens. Washed ashore at Elson Lagoon, September 20, 1949, 1 specimen. On beach at Point Barrow, September 24, 1950, 4 specimens.

Themisto libellula is a circumpolar species which dips down into the North Atlantic to Iceland and southern Greenland. It has been recorded from Bernard Harbor, Northwest Territories, and Dolphin and Union Strait (Shoemaker, 1920); and from Hudson Bay (Shoemaker, 1926). The present records are the first for Alaska. This species measures from 10 to 60 mm., and has been taken as deep as 2,500 m.

THEMISTO ABYSSORUM (Boeck)

Parathemisto oblivia Sars, 1890, p. 10, pl. 5, fig. 1.
Themisto abyssorum Stephensen, 1923, p. 20, chart 4; 1944b, p. 10.

Material collected.—Taken at beach, Point Barrow, September 24, 1950, 1 specimen.

Themisto abyssorum is an arctic species that dips down into the northern part of the North Atlantic and North Pacific. Stephensen gives 17 to 21 mm. as the length of this species. A depth of 3127 m. has been recorded by Sars between Norway and Jan Mayen.

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SMITHSONIAN MISCELLANEOUS COLLECTIONS
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WASHINGTON, D. C., PRECIPITATION OF 1954 AND 1955

By

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(Publication 4210)

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WASHINGTON, D. C., PRECIPITATION OF 1954 AND 1955

By C. G. ABBOT

Research Associate, Smithsonian Institution

This is the eleventh year of these papers regarding precipitation on individual days at Washington, D.C.[1] Last year[2] it was stated that the precipitation of 1952 and 1953 departed greatly from the pattern of previous years. This was shown graphically by a figure. But it was pointed out that the great unexpected peak on the eleventh day of the cycle of 27.0074 days, used in these publications, was much lower in 1953 than in 1952. It has disappeared entirely in 1954, as is shown here in figure 1. A moderate unexpected peak, however, appears on the ninth day of the cycle in 1954. This peak is principally caused by the rain of 1.87 inches which fell on May 3, 1954.

In figure 1 the line AA shows average of precipitation in 1954, and the line BB shows the average in the original tabulation of 1924 to 1941. One notes that the days 1, 2, 3, 5, 12, 13, 16, 18, 22, 26, and 27—eleven out of the original thirteen, which had greater than average precipitation in the tabulations for the years 1924 to 1941—had greater than average precipitation in 1954.

The year 1954 was a dry year in Washington, but the drought was by no means so severe as that in the southern and southwestern United States, though the precipitation in February, July, and September of 1954 was far below normal. It now (January 29) appears likely that the month of January 1955, will be drier than any of those months.

Notwithstanding the peculiarities of Washington precipitation in 1952, 1953, and 1954, just referred to, the prediction published last year, based on a cycle of 27.0074 days, was successful in 1954. The average daily precipitation of the 177 selected preferred days was 1.31 times the average daily precipitation of all other days of 1954. The average daily precipitation on preferred days for 18 years prior to

[1] The first, Smithsonian Misc. Coll., vol. 104, No. 3, 1944.

[2] Ibid., vol. 122, No. 13, 1954.

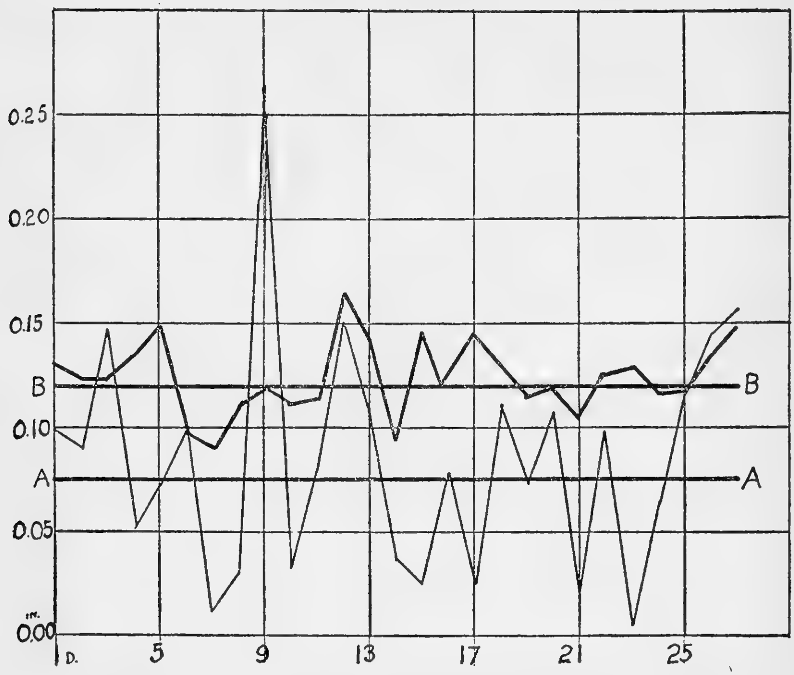

FIG. 1.—Comparison of the 27.0074 cycle of precipitation in 1954 with the basic tabulation of 1924 to 1941.

1952 was 1.46 times the average daily precipitation on all others. The months March, April, July, September, October, November, and December of 1954 were all favorable to the prediction, and January and August but little in the red. Details are given in table 1.

Summary for the year 1954: Total inches, 31.28; percent normal, 77.2; average daily precipitation: preferred days, 0.0975; other days, 0.0746; ratio: 1.31.

TABLE 1.—*Details of precipitation, Washington, D.C., 1954*

Months	Jan.	Feb.	Mar.	Apr.	May	June
Total inches	3.01	0.82	3.84	3.06	3.19	2.29
Average daily, preferred	0.089	0.014	0.175	0.127	0.046	0.001
Average daily, others	0.103	0.044	0.062	0.076	0.144	0.151
Ratio	0.87	0.33	2.82	1.67	0.23	0.01

Months	July	Aug.	Sept.	Oct.	Nov.	Dec.
Total inches	1.66	3.73	0.83	4.24	1.88	2.73
Average daily, preferred	0.071	0.114	0.041	0.246	0.081	0.131
Average daily, others	0.037	0.125	0.016	0.020	0.042	0.052
Ratio	1.92	0.91	2.65	12.30	1.93	2.52

I give in table 2 the 175 dates when higher average precipitation may be expected in 1955 than the average precipitation of all other dates of 1955. The first column, in Roman figures, gives the "preferred" days of the 27.0074-day cycle. The remaining columns give the actual dates in the 12 months of 1955 when these "preferred" cycle dates recur, and when higher than average daily precipitation in Washington may be expected, taking the year as a whole.

The basic tabulation, on which the table rests, began with January 1, 1924, and ended with December 1941. There has been no apparent divergence from this cycle in recent years, except in 1952 and 1953, and it appears to be satisfactory as a basis for 1954, and is used here for 1955. So the decimal 0.0074 seems correct for over 30 years. This cycle corresponds closely with the average period of rotation of the sun, and was suggested by a corresponding period in the Smithsonian measures of the solar constant of radiation. The cycle is more strongly marked in these measures in some years than in others.

TABLE 2.—*Washington precipitation, 1955*

	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
I	20	16	15	11	8	4	1,28	24	20	17	13	10
II	21	17	16	12	9	5	2,29	25	21	18	14	11
III	22	18	17	13	10	6	3,30	26	22	19	15	12
IV	23	19	18	14	11	7	4,31	27	23	20	16	13
V	24	20	19	15	12	8	5	1,28	24	21	17	14
XII	4,31	27	26	22	19	15	12	8	4	1,28	24	21
XIII	5	1,28	27	23	20	16	13	9	5	2,29	25	22
XV	7	3	2,29	25	22	18	15	11	7	4,31	27	24
XVII	9	5	4,31	27	24	20	17	13	9	6	2,29	26
XVIII	10	6	5	1,28	25	21	18	14	10	7	3,30	27
XXII	14	10	9	5	2,29	25	22	18	14	11	7	4,31
XXVI	18	14	13	9	6	2,29	26	22	18	15	11	8
XXVII	19	15	14	10	7	3,30	27	23	19	16	12	9

SMITHSONIAN MISCELLANEOUS COLLECTIONS
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SIXTY-YEAR WEATHER FORECASTS

By

C. G. ABBOT

Research Associate, Smithsonian Institution

(Publication 4211)

CITY OF WASHINGTON
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SIXTY-YEAR WEATHER FORECASTS

By C. G. ABBOT

Research Associate, Smithsonian Institution

I wish to show that by employing a family of periods (which were discovered to exist in variations of the solar constant of radiation[1]) general weather forecasts of temperature and precipitation have been made with success many years from their base. I do not claim that the method is equally successful for all stations, or that it is successful at any station at all times, or that it deals with detailed forecasts, or with short times like a week or a month. But I hope to show by use of records of St. Louis precipitation over a course of 100 years, supported by shorter excerpts from records of temperature and precipitation at several stations, that, from a seasonal point of view, forecasts for as much as 60 years from base, and over long intervals of time, such as 5 to 25 years, are successful and give high correlations with events.

I shall present the matter in two parts. In the first, by means of charts and correlation coefficients, I shall illustrate and support the claims just stated. In the second, I shall disclose in considerable detail the method now used to obtain the results.

1. EVIDENCES SUPPORTING MY CLAIMS

Before presenting results I must state several propositions:

1. Twenty-three members of a family of regular periods are used. All of these periods, to within 1 percent, are exact submultiples of $22\frac{3}{4}$ years.

2. This family was discovered in fluctuations of the solar constant of radiation.[2]

[1] This term has long been used to denote the intensity of the solar radiation outside our atmosphere at mean solar distance. Daily Smithsonian determinations of it for more than 30 years have shown that it is not quite constant but varies over a range exceeding 1 percent.

[2] From other types of phenomena, including, among others, basal human pulse rates, many additional members of the family are known. In all, more than 40 members have been discovered. All are within 1 percent submultiples of $365\frac{1}{4} \times 22\frac{3}{4}$ days.

3. To those who hold that the observed fluctuations in the earth's supply of radiation from the sun, which I claim to be periodic, are too small in percentage to affect weather appreciably, I remark that it makes no difference how the family of periods was discovered, or whether the effects that I ascribe to solar variation are really of solar causation. *These 23 periods exist in temperature and precipitation, however they may be produced.* But in Part 2 I shall advance suggestions tending to explain the large weather effects from small solar changes.

4. The forms and amplitudes of these periods in precipitation and temperature are determined by tabulations of monthly records, published in "World Weather Records." Over 1,000 months of records, ending with December 1939, are used in all tabulations. They fix mean forms and amplitudes of all the periods, applicable at all times.

5. Every precipitation or temperature value forecasted is obtained by a synthesis of about 23 terms. Each term depends on more than 1,000 monthly records. In the study of St. Louis temperature and precipitation, 1,032 months, of the years 1854 to 1939, were employed to establish the basis, which, accordingly, centers on the year 1897.

6. A determination by such a synthesis of the march of precipitation at St. Louis for any selected year is of the nature of a prediction, backward or forward, from 1897. Even if the selected year falls between 1854 and 1939, its own observed monthly mean precipitation or temperature, though used in computing the basis of the forecast, can have but $\frac{12}{1{,}032} = 1\frac{1}{6}$ percent influence on the forecast.

7. Knowing that any curve, even the profile of a girl's face, can be fairly represented by a Fourier's series of sufficient number of terms, some critics, at first sight, may think it nothing remarkable that, with 23 terms, the march of precipitation or temperature can be well represented. But the proposition (6) has nothing in common with such a Fourier series. The girl's profile would be built by a Fourier's series solely on measurements taken *within* that profile. No satisfactory representation of it could be made by a Fourier's series made from measures on over 1,000 *other* girls. In my case 1,032 monthly records govern the synthesis for each and all years, and over 1,000 of them lie *outside* any selected year to be forecasted.

8. Of 100 years of St. Louis precipitation forecasted, 70 seem fairly satisfactory and yield high correlation coefficients with the events. The failure of the other 30 is reasonably explained.

9. As shown by Dr. W. J. Humphreys in his "Physics of the Air," figure 227, great volcanic eruptions, which throw high columns of

vapor and dust, profoundly modify weather. He cites the first four cases in the following list, and I add several more.

Approximate dates	Eruptions
1856	Cotopaxi and others.
1883-1890	Krakatoa and others.
1901-1904	Pele, Santa Maria, Colima, and others.
1912	Katmai.
1924 and 1928	Many great eruptions.
1930	Great eruptions.
1947	Niuafoo Island.

10. Of 30 unsatisfactory years, in 100 years of synthesis of St. Louis precipitation, these lie in groups as follows: 1854 first half; 1856 to 1860; 1887 to 1889; 1900; 1901; 1905 to 1907; 1912 last half, 1913 first half; 1915 to 1917; 1920; 1923 to 1926; 1930; 1940 to 1950. It will be seen that almost all these unsatisfactory intervals fall either when tremendous volcanic eruptions occurred or when there was tremendous use of explosives in war or explosions of atomic bombs. As will be pointed out in Part 2, atmospheric changes alter the lags in the weather effects of all solar impulses, and of course unequal periods have unequal lags. These unusual atmospheric disturbances may very well have mixed up the terrestrial responses to the 23 periods so as to cause the events to differ from the predictions.

With these propositions stated, I go on to present evidences justifying my claims.

Figure 1 is a reproduction of an actual synthesis, made to determine the march of precipitation at St. Louis, Mo., over the five years 1875 to 1879 inclusive. Its 22 columns of precipitation departures are in percentages of normal, expressed in tenths of a percent, and are mean values of the periodic percentage departures derived from 1,032 months and meticulously arranged with regard to phases. The 22 periods used in St. Louis precipitation are shown in table 1.

TABLE 1.—*Periods used in St. Louis syntheses, in months*

No.	1	2	3	4	5	6	7	8	9	10	11
Period	4-1/3	5-1/8	6-1/15	7	8-1/8	9-1/6	9-3/4	10-1/10	10-6/10	11-1/5	13-1/10
No.	12	13	14	15	16	17	18	19	20	21	22
Period	13-6/10	15-1/6	22-4/5	24-4/5	30-1/3	34-1/5	38-8/10	45-1/2	27-1/4[3]	68-1/2	91

In some other syntheses a period of $19\frac{1}{2}$ months was found to be overriding the period of 38⁸⁄₁₀ months. In some, the period of $54\frac{1}{2}$ months was strong, and its half, $27\frac{1}{4}$ months, unimportant.

[3] It was found that $54\frac{1}{2}$ months gave no appreciable departures when relieved of the overriding period of $\frac{54\frac{1}{2}}{2} = 27\frac{1}{4}$ months.

The reader will note from figure 1 that the ranges of the periodic terms in St. Louis precipitation vary from 5 to 25 percent of normal precipitation, and the precipitation itself varies through a range of

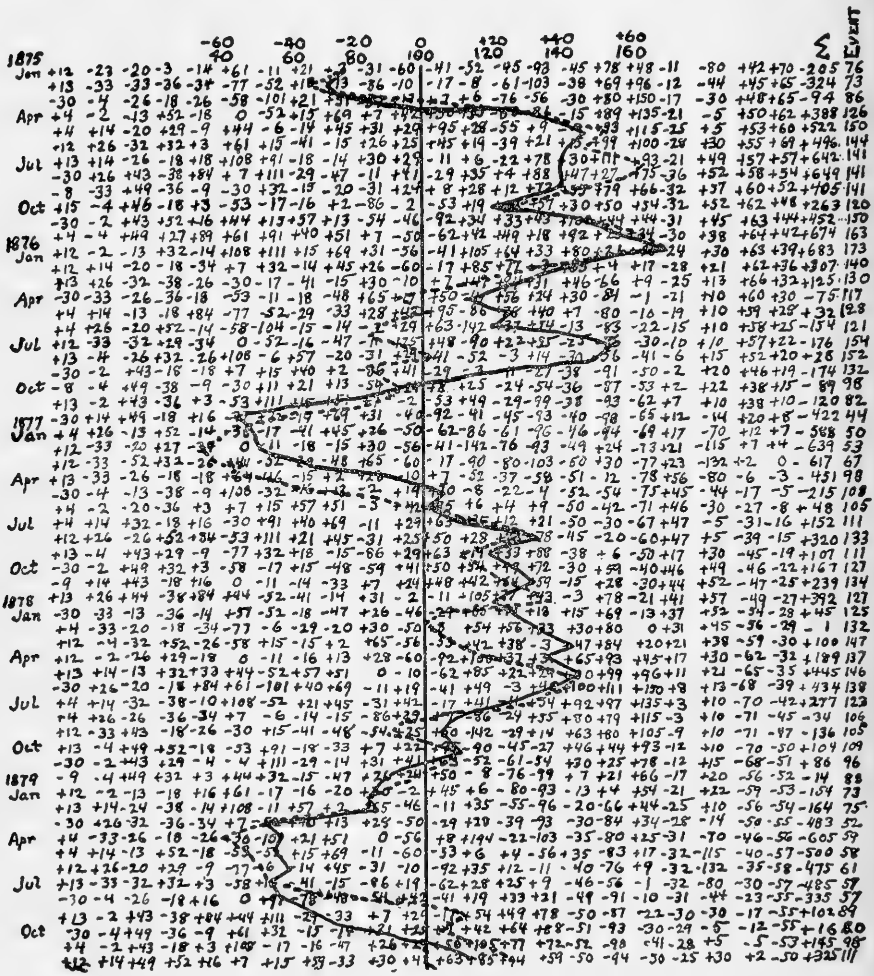


FIG. 1.—Facsimile of computation of St. Louis precipitation, 1875-1879, compared with the observed precipitation as percentage of normal. Data from monthly mean precipitation smoothed by 5-month running means. Dotted curve from summation of 22 regular periodicities, determined as averages over the 84-year epoch, 1854-1939. Full curve, the event.

over 130 percent of normal. Yet all the work, as stated above, rests on smoothed 5-month running means, which, of course, greatly diminishes the range from that of observed monthly mean values.

The correlation coefficient over these 5 years, between synthesis

and event, is 80 ± 5.2 percent. The average epoch of the synthesis, $1877\frac{1}{2}$, is $19\frac{1}{2}$ years earlier than the average basis on which the periods rest, 1897.

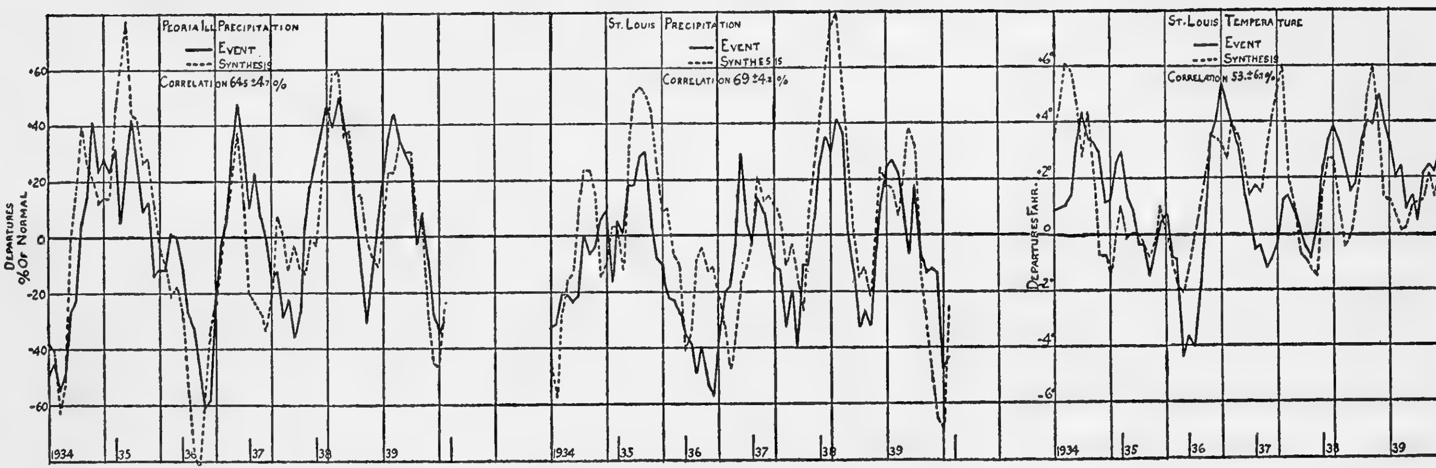
Figures 2 and 3, representing the percentage departures in precipitation at Peoria,[4] Ill. (about 100 miles from St. Louis), and St. Louis for the 6 years 1934 to 1939, are included with figure 4, representing departures in temperature at St. Louis for the same years, in order that these several results may easily be compared. The syntheses were made with the same periods given in table 1, except as stated in the paragraph which next follows table 1. The reader will see, as in figure 1, that even in small details the syntheses often follow similar details of variation in the events. He will also note the very close similarity between the precipitation at St. Louis and that at Peoria, during these 6 years, as well as how closely the syntheses, based on the mean year of records, 1897, 40 years earlier, follow the actual events.

It is a severe test to compute correlation coefficients, for often one or two months' displacements of features, between synthesis and event, make great differences in ordinates of the curves and strongly reduce correlation coefficients. However, all three of these syntheses, 40 years from their mean bases, give correlation coefficients between 50 and 70 percent, with probable errors from $1/7$ to $1/15$ of the coefficients. It is to be noted as surprising that the synthetic temperature curve of St. Louis averages 2° F. above the event in these 6 years. One would have expected it below rather than above. But possibly if longer periods, 136 and 273 months, had been used, the displacement would have disappeared. This displacement of scale was taken account of in computing the correlation coefficient for St. Louis temperature. No such adjustment was required in figures 1, 2, and 3, or in figure 5 to follow. The reader will note that the *ranges*, in all these figures of synthesis and event, are substantially the same.

Figure 5 gives the synthesis and event for St. Louis precipitation from 1860, which, as mentioned above, was the last of several unsatisfactory years, to 1887, the first of several unsatisfactory years. As stated above, these unsatisfactory intervals may be reasonably attributed to the violent eruptions of the volcanoes Cotopaxi in 1856 and Krakatoa in 1883. The good interval, 1861 to 1886, according to Humphreys, was unusually free from violent volcanic eruptions.[5] I

[4] The Peoria synthesis is made from a new reduction, with latest improvements over that given in Smithsonian Misc. Coll., vol. 117, No. 16, 1952.

[5] It takes several years, apparently, for a great volcanic eruption many thousands of miles away to produce its effects on phases of periodicities in St. Louis precipitation.



FIGS. 2, 3, and 4.—Three 6-year predictions 40 years in advance. Precipitation (Peoria and St. Louis) and temperature (St. Louis) computations 1934-1939 compared to the events. Precipitation, percentages of normal; temperature, departures from normal. Dotted curves, computed; full curves, events. All from 5-month smoothed running means.

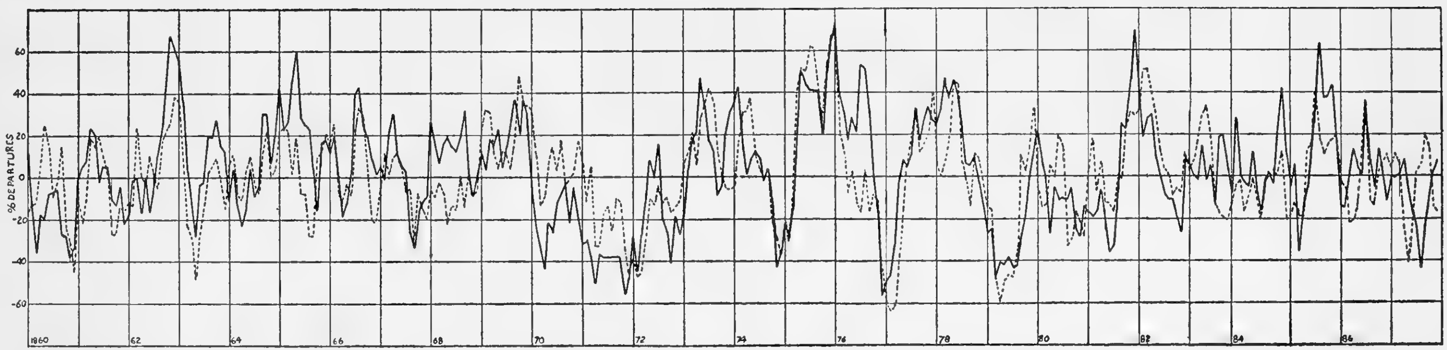


FIG. 5.—Synthesis of computations, 1860-1887, of St. Louis precipitation compared to the event. Dotted curve, computed; full curve, the event. All from 5-month smoothed running means.

give in table 2 the mean values of the average deviation in figure 5 for seven 4-year intervals, and the general averages of these seven quantities, which may be compared to the range of precipitation, 130 percent of normal.

The range of precipitation, 1860 to 1887, in 5-month running means, was a little over 130 percent of normal precipitation.

I cannot but believe that if similar results to figure 5 were computed for perhaps 50 selected stations over the United States, areas of equal departures from normal precipitation could be mapped years in advance, which, unless vitiated by world wars or violent volcanic eruptions, would be of much practical use.

I complete Part 1 with a very ambitious prediction of precipitation at St. Louis and Peoria shown in figure 6. Counting from 1897, the middle of their common interval of preparation, the predictions, which

TABLE 2.—*Average deviations, in percentages of normal precipitation, between prediction and event for 28 years' synthesis of St. Louis precipitation. Means of individual monthly differences*

Time interval	1860-63	1864-67	1868-71	1872-75	1876-79	1880-83	1884-87	General
Average deviation	±17	±14	±22	±13	±17	±17	±17	±17
Scale displacement. Event minus prediction	+5	+6	−8	−1	+8	−2	+6	+2

end with 1957, extend 60 years from their mean base, and 18 years beyond December 1939, the last month used in the preparation of that base.

Since I have not employed the long periods of $11\frac{3}{8}$, $22\frac{3}{4}$, and $45\frac{1}{2}$ years in these syntheses, I feel warranted in adjusting the levels of the two predictions to suit the prevailing conditions of precipitation, 1952 to 1954. This involved lowering the St. Louis curve of synthesis, 1952 to 1957, bodily, by 20 percent of the normal precipitation. I made no change for Peoria.

Although the features are similar, it will be noted that observed precipitation *precedes* synthesis at St. Louis in 1952 by four months and *follows* synthesis at Peoria by four months in 1952 and 1953. Yet almost throughout the 6 years of prediction, St. Louis and Peoria syntheses are nearly in step, although resting on two independent series of observations 80 years long, which ended in 1939. These displacements, between prediction and event, similar to those remarked in earlier papers, are puzzling. Perhaps the solar mechanism that operates has slips, making events early or late, as has long been noted in the $11\frac{3}{8}$-year sunspot period.

We must wait three years to compare these predictions fully with the events. As a caution therein, it will be recalled that I deal entirely with 5-month running means.

One notes with pleasure that there is promise of approaching relief from the prevailing distressing drought in 1957. Its approach and advance from 1952 are well shown by St. Louis prediction.

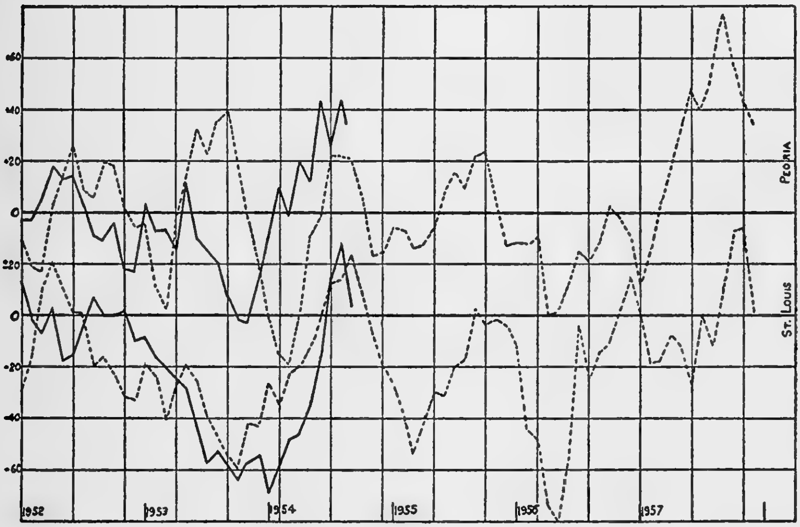


FIG. 6.—Predicted precipitation, Peoria (upper) and St. Louis (lower), 1952-1957, from mean forms of 22 periodicities over the epoch 1854-1939. End of prediction 18 years after 1939 and 60 years after middle of base, 1897. Dotted curves, prediction; full curves, event. Horizontal lines represent normal precipitation. Drought indicated ending 1957.

2. DETAILED METHOD OF FORECASTING

The method rests on the discovery of a family of regular periodicities in weather and other phenomena, all, to within 1 percent, exact submultiples of $22\frac{3}{4}$ years. To express the matter more precisely, the master period is $22\frac{3}{4} \times 365\frac{1}{4}$ days. Not until recently was I aware that the period I found several years ago in New York and Washington temperatures, 6.6485 days,[6] is itself a member of this family. For $22\frac{3}{4} \times 365\frac{1}{4}$ days is 8309.44 days; which divided by $1250 = 6.64754$ days, a value less than 1 percent different from the other. My friend Dr. F. P. Marshall found a period of 212 days, and 15 exact submultiples of it, in a record of 3 years of daily basal pulse rates. Seven months, a period used in all of my syntheses, is $\frac{7}{12} \times 365\frac{1}{4}$ days $= 213.3$

[6] Smithsonian Misc. Coll., vol. 111, No. 17, 1950.

days. This differs by only $\frac{2}{3}$ percent from Dr. Marshall's longest pulse period. Hence all the pulse periods found are aliquot parts of $22\frac{3}{4}$ years.

The original observation that led me to discover the family of periods in weather was the discovery of more than 20 of them in measures of the solar constant of radiation. Meteorologists and others have expressed doubt that the evidence warranted this result. But if it did, they say, the solar variations claimed, generally of the order of 1/10 percent of the solar constant, are too small appreciably to affect weather.

With much recent experience in the study of this family of periodicities, I have revised and hope to publish soon my study of more than 30 years of daily measures of the solar constant of radiation. This revision has yielded highly satisfactory results, and I believe the evidence of the existence, in these measures, of the family referred to has become more convincing.

But as regards the adequacy of these solar variations to affect weather, I made a suggestion in my paper "Solar Variation, a Leading Weather Element."[7] It is this: Temperature depends on wind direction. Wind direction depends on orientation with respect to atmospheric cyclones. H. H. Clayton showed some 25 years ago, by extensive tabulations of atmospheric pressure, that the position of cyclones varies with the intensity of solar radiation.

I have been interested in checking the first step in this sequence. My assistant, Mrs. I. W. Windom, collected records of the prevailing winds and temperature departures from the normal at Washington, D. C., for about 1,600 successive days. Of these the prevailing wind could not be determined on about 100 days. The relation of prevailing wind to temperature departures for the remaining 1,500 days is given by figure 7. The result is quite definite. The temperature is about 12°.5 F. higher when the wind is south, or southwest, than when it is northwest. That the values in figure 6 are not symmetrical about zero is merely resulting from the characteristics of the years chosen.

Still it makes no difference for the acceptance of the results of my present paper whether meteorologists concede solar variation to be the cause. The family of periodicities, to a number of nearly 30, *has been demonstrated in weather,* and at least 24 of them have been used in the several syntheses I have shown in illustrations.

The periods are not apparent in weather at first sight for several reasons. First, the normal values published with weather records are

[7] Smithsonian Misc. Coll., vol. 122, No. 4, August 1953.

computed from *all* the records without regard to the sunspot frequency prevailing. At Peoria the rainfall is about 7 percent higher at sunspot maximum than at sunspot minimum. If a long term of years of monthly records is being used to compute such a period as 7 months, mentioned above, the tabulation at Peoria would be thrown into confusion, if published normals, taking no account of this, were used. My first step therefore is to compute new normals. I have chosen to use 20 Wolf sunspot numbers as the dividing line between high and low sunspot prevalence. Table 3 gives the normals for Peoria, Albany, Washington, and St. Louis according to my revisions.

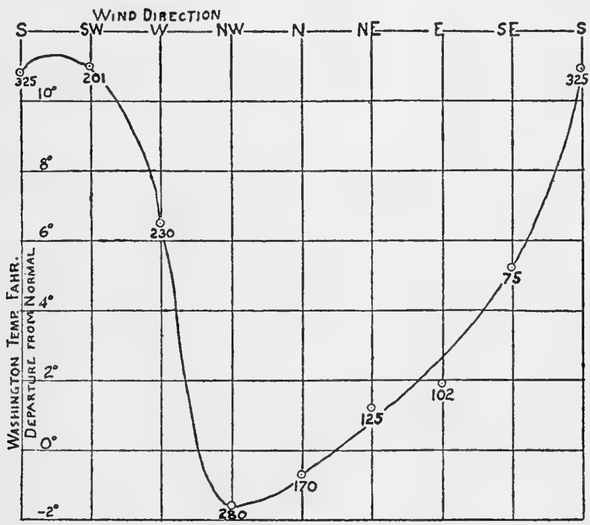


FIG. 7.—How Washington, D. C., temperature depends on wind direction. Temperatures Fahrenheit, from about 1,500 consecutive days.

Second, phases depend on the season of the year.[8]

Terrestrial effects from solar causes lag behind the actuating causes. Thus the hottest part of summer falls many weeks after the June solstice, and the warmest part of the day occurs several hours after noon, at most stations. Lags for my periods depend, in the first instance, on the season of the year. It is not possible to fully compensate for this. As a compromise measure, I divide the year into three parts—January to April; May to August; September to December.

Third, phases depend on sunspot frequency.

[8] I published this observation in the year 1944 (see Smithsonian Misc. Coll., vol. 104, No. 5, p. 27).

Sunspots are like machine guns, bombarding the earth with multitudes of ions. These ions act as centers of condensation for dust and water vapor, thus altering the state of the atmosphere, the lags, and the phases of periods in weather. As a compromise measure, I use a dividing line at 20 Wolf numbers in my tabulations.

TABLE 3.—*Weather normals, taking account of sunspot frequency (precipitation given in inches)*

Sunspot frequency	Station and element	Jan.	Feb.	Mar.	Apr.	May	June
High	Peoria precipitation [9]	1.84	1.87	2.80	3.62	3.90	4.04
Low		1.58	1.71	2.82	2.79	3.88	3.24
High	Albany precipitation	2.56	2.52	2.64	2.45	3.03	3.51
Low		2.32	2.09	2.96	2.91	3.13	3.81
High	St. Louis precipitation	2.54	2.49	3.29	3.72	4.32	4.08
Low		2.11	2.46	3.90	3.79	4.36	3.98
High	Washington temperature	33°.8	35°.6	43°.1	53°.3	63°.9	72°.4
Low		33.7	34.6	42.7	53.9	64.0	72.5
High	St. Louis temperature	30°.9	35°.1	44°.6	55°.6	66°.0	74°.4
Low		32.7	38.8	43.3	56.0	66.2	75.6

Sunspot frequency	Station and element	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year Total
High	Peoria precipitation	3.70	3.06	3.56	2.22	2.36	1.91	34.88
Low		3.40	2.66	3.85	2.56	2.22	1.88	32.59
High	Albany precipitation	4.02	3.64	3.18	2.69	2.76	2.09	35.09
Low		3.43	3.89	3.38	3.19	2.75	2.32	36.18
High	St. Louis precipitation	3.13	3.15	3.31	2.77	2.87	2.36	38.03
Low		3.46	3.52	3.32	2.71	2.68	2.54	38.83
								Year Mean
High	Washington temperature	76°.5	74°.9	68°.3	56°.4	45°.5	35°.3	45.90
Low		77.2	74.1	68.1	56.9	46.0	36.4	55.01
High	St. Louis temperature	79°.1	77°.5	70°.5	57°.7	44°.5	34°.8	55.89
Low		80.4	77.4	69.8	58.3	45.5	35.7	56.64

Fourth, phases depend on human occupancy, and other secularly changing conditions. As a compromise measure, in these tabulations I use 1900, approximately, as a dividing line.

These compromise measures lead me to make 12 tables each for all the periods, 13 in number, which lie below 20 months. As the num-

[9] These values are those published in the paper cited in note 4 above. But they are so different from those of other stations, that I feared they were partly erroneous. A revision, however, confirms these.

ber of repetitions has to be large to eliminate accidental influences, and more especially to eliminate the influence of over 20 other periods on the one being tabulated, I omit considering the time of the year in periods from 20 to 50 months. Normally there are six tables of that class. For the three still longer periods I omit considering the sunspot frequency. Thus the tabulations involve $12 \times 13 + 6 \times 4 + 3 \times 2 = 186$ tables for the synthesis of monthly precipitation.

The next complication comes from the need to have many repetitions, in order to eliminate interference effects of over 20 periods upon the one being evaluated. If the 12 tables for periods of less than 20 months each stood alone, the repetitions would be too few. As a compromise measure, I make the assumption that the tabulations at different times of the year, and at different epochs before and after 1900, would be nearly the same for a given period, except in phase. With this assumption, I can combine six tables into one, merely altering the phases of the separate tabulations into the most harmonious relation. I then use the mean values representing these sixfold combinations as the representatives for all occurrences of the periods being studied. But I carefully restore the mean assemblies to the phases which each of their six constituents had, as I tabulate the periods in my synthesis.

To make all this clearer, I now give, in tables 4 and 5, and figure 8, an actual tabulation for the $11\frac{1}{5}$-month period in St. Louis precipitation. I use certain symbols which I will first explain. For the three selected times of the year, and for before and after 1900, I use $a_1\ b_1\ c_1$, $a_2\ b_2\ c_2$, when sunspots $>$ 20 Wolf numbers, and $a_1^1\ b_1^1\ c_1^1$, $a_2^1\ b_2^1\ c_2^1$ when sunspots $<$ 20 Wolf numbers. If, in tabulating, I move values to bring all six determinations to harmonious phases, I use the symbols o k, $\downarrow$, $\uparrow$, to indicate if the phases are left alone, or moved later or earlier. I add the numbers 1, 2, 3, etc., as subscripts, to indicate the number of lines of displacement. With these explanations given, table 4 shows a determination of "a_1." Table 5 shows the assembly of the six mean columns "$a_1\ a_2\ b_1\ b_2\ c_1\ c_2$," which cover all times between 1854 and 1949 when Wolf sunspot numbers exceeded 20. Table 6 compares these "departures" of table 5 with similar ones derived for Wolf numbers $<$ 20. Table 7 shows the displacements of phases made to harmonize in table 5, and those made to harmonize phases in the corresponding table (not shown) dealing with all times from 1854 to 1939, when Wolf numbers $<$ 20. These displacements must all be restored when using the "Departure" columns for syntheses of precipitation. This step will appear, so far as it concerns a time when Wolf numbers exceeded 20, if one examines figure 1, an actual synthesis of St. Louis precipitation, covering the years 1875 to 1879.

TABLE 4.—*Determination of "a_1" (see text), 11-1/5-month period, St. Louis precipitation*

Mar. 1868	Feb. '69	Jan. '70	Apr. '80	Mar. '81	Mar. '82	Feb. '83	Jan. '84	Apr. '94	Mean a_1
									101.9
115	111	129	73	84	128	100	101	76	98.0
107	103	97	95	94	129	98	97	62	94.3
115	118	79	89	74	108	115	95	56	91.9
120	114	69	90	64	101	98	111	60	88.4
115	123	57	89	67	92	105	93	55	89.1
112	104	79	95	93	89	87	83	60	98.3
119	112	73	77	125	89	119	97	74	102.2
132	127	88	71	123	80	120	102	77	100.0
103	137	94	86	193	73	107	96	61	102.2
91	120	97	83	169	108	92	123	61	105.6
101	137	78	81	145	104	128	141	51	108.2
				(119)					

TABLE 5.—*Assembly of "a_1, a_2, b_1, b_2, c_1, c_2." Decimals neglected*

$a_1$ok	$a_2$ok	$b_1\downarrow_2$	$b_2\uparrow_2$	$c_1\downarrow_3$	$c_2\downarrow_3$	Sum	*Sum* 6	Departure percent
1019	1014	1079	986	1204	1066	6368	1061	+ 5.8
980	991	1058	966	1097	1085	6177	1030	+ 2.7
943	988	1132	939	1067	995	6064	1011	+ 0.8
919	924	1026	903	1016	1090	5878	980	− 2.3
884	905	971	830	1021	1088	5399	933	− 7.0
891	818	1080	816	1043	994	5642	940	− 6.3
983	867	1004	828	998	980	5660	943	− 6.0
1022	922	926	880	1079	1019	5848	978	− 3.1
1000	1007	1041	894	1078	1072	6022	1004	+ 0.1
1056	1042	1111	964	1193	1021	6387	1064	+ 6.1
1082	1132	1059	998	1178	1049	6448	1083	+ 8.0

Sum 11027
Sum ÷ 11 = 1003

Range 14%

TABLE 6.—*Departures, table 5, and departures when Wolf No. < 20*

Wolf No..	1	2	3	4	5	6	7	8	9	10	11	Range
> 20	+5.8	+2.7	+0.8	−2.3	−7.0	−6.3	−6.0	−3.1	+0.1	+6.1	+8.0	15%
< 20	+3.0	+6.5	+2.8	0.0	−1.1	−3.1	−8.6	−5.9	+0.7	+3.1	+2.6	15%

TABLE 7.—*Comparing subscripts of position* "a_1 a_2 b_1 b_2 c_1 c_2" *with those of* "a_1^1 a_2^1 b_1^1 b_2^1 c_1^1 c_2^1"

First lot .... $a_1$ok $a_2$ok $b_1\downarrow_2$ $b_2\uparrow_2$ $c_1\downarrow_3$ $c_2\downarrow_3$
Second lot .... a_1^1ok $a_2^1\uparrow_4$ $b_1^1\downarrow_4$ b_2^1ok $c_1^1\downarrow_1$ c_2^1ok

The tendency to make mistakes, in tabulating and adding for syntheses, will be very apparent if one reflects that, when a change comes between Wolf numbers $\gtreqless 20$, the computer must change from tables like table 5 to their counterparts for Wolf numbers < 20; that at all times he must remember to reverse the displacements indicated by the arrow subscripts of displacements in those tables; that for periods not of whole numbers of months he must insert or reject a month from time to time; that he must always start a column in the correct phase; that when adding the 22 or more columns, as in figure 1, he must not only be sure to correctly read the values, but also their algebraic signs. With all the care I can muster, I have always found many mistakes, of one or another of these sorts, when rechecking the whole process.

I give in figure 8 the "departure" curves like those indicated in table 5, as found for the $11\frac{1}{5}$-month period at St. Louis, when Wolf numbers > 20. The reader will see from table 6 relating to Wolf numbers $\gtreqless 20$ that, though two months displaced in phase, the two series, coming from entirely different data, are identical in range and nearly identical in form. These pleasing similarities between such pairs of series for Wolf numbers $\gtreqless 20$, representing all the 19 or more periods which can be thus compared, are almost invariably found.

This in itself is evidence that the existence in weather of the large family of periodicities, aliquot parts of $22\frac{3}{4}$ years, has a sound basis. For in all tabulations of many values, leading to a periodic result, the careful computer always divides the data into two or more sections, to see if the several groups of data yield the same periodic result. As just stated this criterion is well met in this research.

But there is another evidence of great weight. The ranges of the periodic curves in weather are not small. In precipitation at St. Louis, Peoria, and Albany, the ranges of the periods run from 5 to 25 percent. This is a very great matter, if the critic is inclined to think of accidental error, and to scout my whole investigation as trifling or spurious.

In the third place, as seen over the 26 good years shown in figure 5, the great features, and many of the minor features, found in the event are seen to be also in the synthesis, and in very nearly the same amplitudes and positions. That this does not hold true for 30 out of 100 years of synthesis of St. Louis precipitation has been reasonably explained above as probably caused by tremendous disturbances of the atmosphere by violent volcanic outbursts, by the prodigal bombing during the two world wars, and the Korean war, and by the tests in recent years of atomic bombs in different parts of the world.

We now come to a fourth line of evidence even more convincing. It is held that the large family of periodicities are all, to within 1 percent, aliquot parts of $22\frac{3}{4}$ years. If so, periods of $\frac{1}{4}$, $\frac{1}{8}$, and $1/12$ of $22\frac{3}{4}$ years, and similar groups of periods of various lengths, are also related by integral numbers to each other and to $22\frac{3}{4}$ years. Accord-

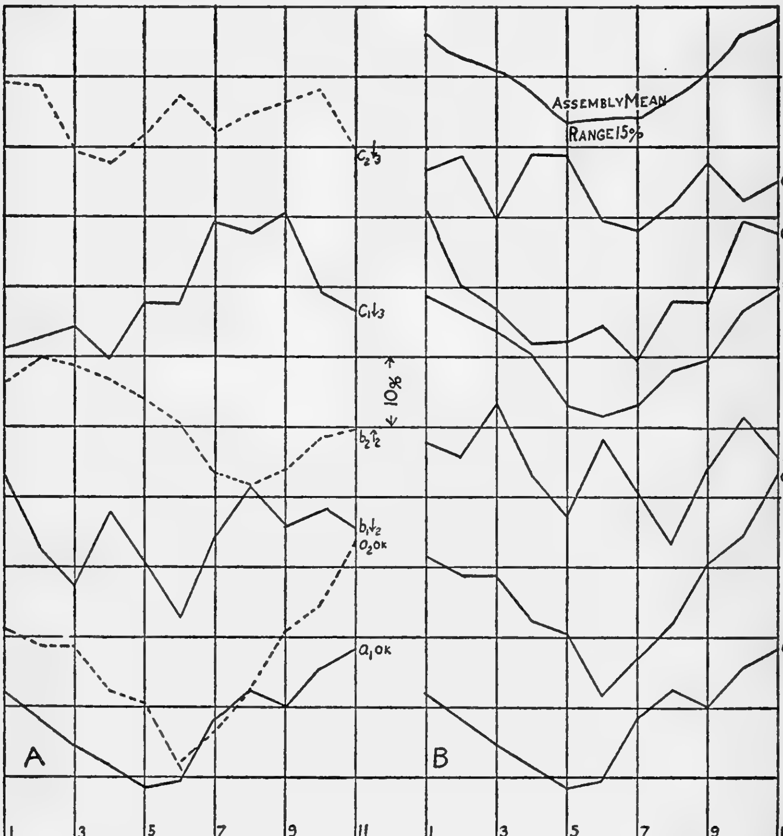


FIG. 8.—The $11\frac{1}{5}$-month periodicity in St. Louis precipitation as averaged from six independent determinations. A, Wolf numbers above 20; B, Wolf numbers below 20.

ingly, when a tabulation is made to determine the form and range of one of the longer periodicities, we may often find several shorter periods, harmonics of it, riding on the long curve. If these shorter periods are not removed, the longer ones are often unrecognizable.

This is the case. I shall give several illustrations of it. The first is from the period of $68\frac{1}{2}$ months, shown in figure 9. A and B are

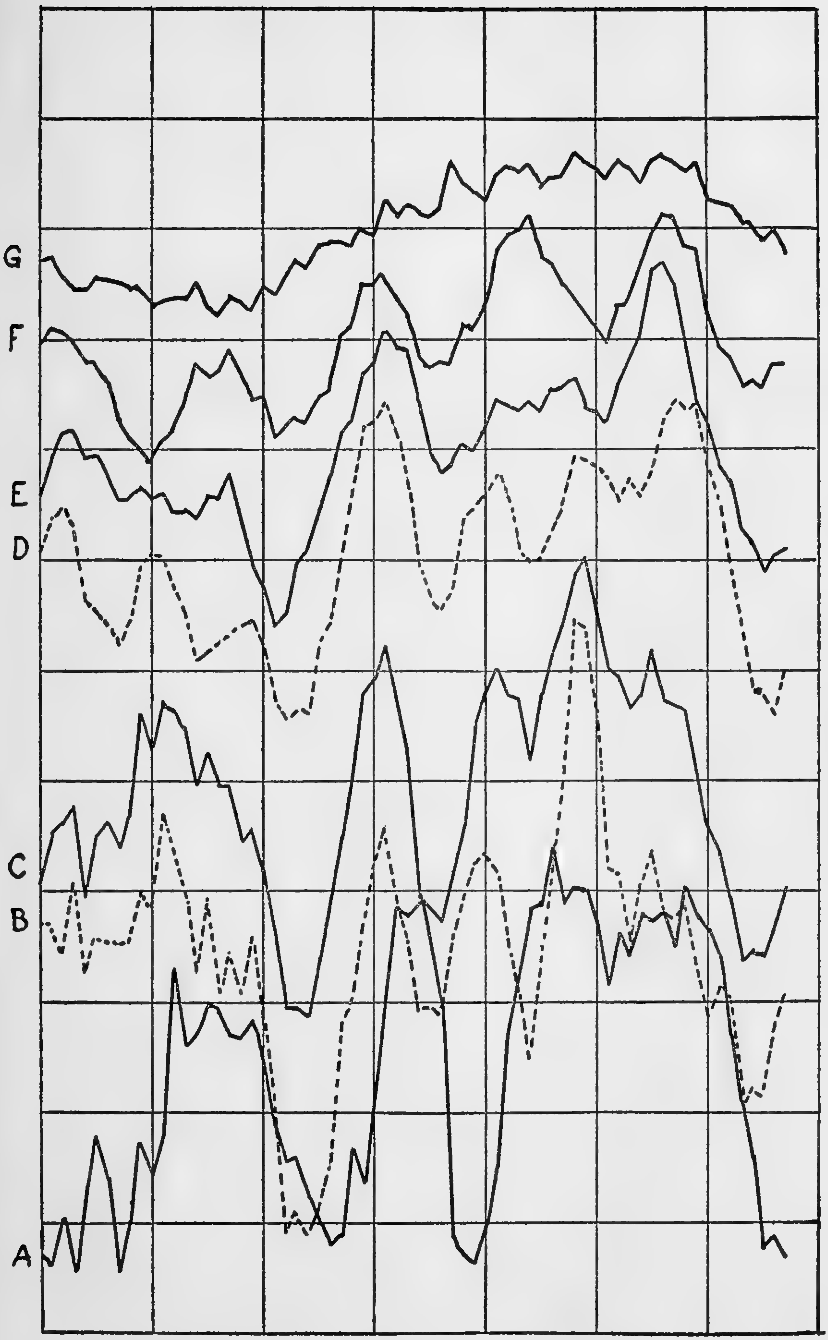


Fig. 9.—The $68\frac{1}{2}$-month periodicity in St. Louis precipitation as modified by shorter periodicities, aliquot parts of $68\frac{1}{2}$ months.

means—A of 8 repetitions of consecutive values for $68\frac{1}{2}$ months prior to 1900, and B of 7 repetitions of it after 1900. They show considerable similarity, but the phase of A is, on the whole, 3 months farther advanced than B. If we displace A backward 3 months, and take the mean of the two determinations, curve C results. Curve C gives an indication of three maxima. Taking the average of these and subtracting, we get curve D. Curve D obviously presents seven humps somewhat similar and nearly equally spaced. Averaging these features of curve D and subtracting, we get curve E. Now the halves stand out very plainly. Averaging the halves of curve E and subtracting, we get curve F. It obviously contains five similar parts. Having determined their average, and subtracting, we have curve G. It possibly has 11 maxima, but is so nearly smooth that I merely drew a smooth line and used values from that in my synthesis of St. Louis precipitation. The range of this $68\frac{1}{2}$-month period, curve G, is 13 percent. Thus this single diagram presents for us five submultiples of $22\frac{3}{4}$ years, viz, $\frac{1}{4}$, $\frac{1}{8}$, 1/12, 1/20, and 1/28, none of which would be apparent to one who was unacquainted with the family of periods related to $22\frac{3}{4}$ years.

I now take the $30\frac{1}{3}$-month period in Peoria [10] precipitation for illustration. To somewhat abbreviate the presentation, I start with *departures from mean percentages of normal precipitation.* That is, using the symbols above explained and used, I start with a_1, a_2, a_1^1, a_2^1. In figure 10, A, B (left) and C, D (right) are curves corresponding to these four symbols. I shift curve A backward 5 months to combine with curve B. This reduction gives us curve E. Proceeding with curve E, I detect in it the half of $30\frac{1}{3}$ months. Removing this, we get curve F. In curve F a period of $30\frac{1}{3} \div 3$ months is seen. Removing this period, we get curve G. Its range is 7 percent. Proceeding with curves C and D, they seem best adapted to be treated separately. From curve C I remove its half-period, yielding curve H, and from curve H its third-period, yielding curve I. Treating curve D in the same way, curves J and L result. I now combine results I and L, by moving I 6 months forward and taking the mean. It yields curve M. And now a period of $30\frac{1}{3} \div 7$ months is seen. Removing it, I derive curve N. It has a range of 10 percent. Its phase is about 8 months in advance over curve G, but the two forms are similar.

As another example I take the period of $45\frac{1}{2}$ months, which is $\frac{1}{6}$ of

[10] Having had much experience since my Peoria publication (Smithsonian Misc. Coll., vol. 117, No. 16, 1952) I have revised that synthesis. This present illustration is from the revised tabulations, and so are all Peoria data in this paper.

$22\frac{3}{4}$ years, as represented in Peoria precipitation. I select this because, as I have said above, the periodicities run from 5 to 25 percent of normal precipitation. As we shall see, the amplitude of this period, for sunspots $>$ 20 Wolf numbers, is 22 percent; and for sunspots $<$ 20 Wolf numbers, it is 25 percent, at Peoria. The curves are shown in figure 11. At the left I plot results a_1, a_2, for Wolf numbers $>$ 20,

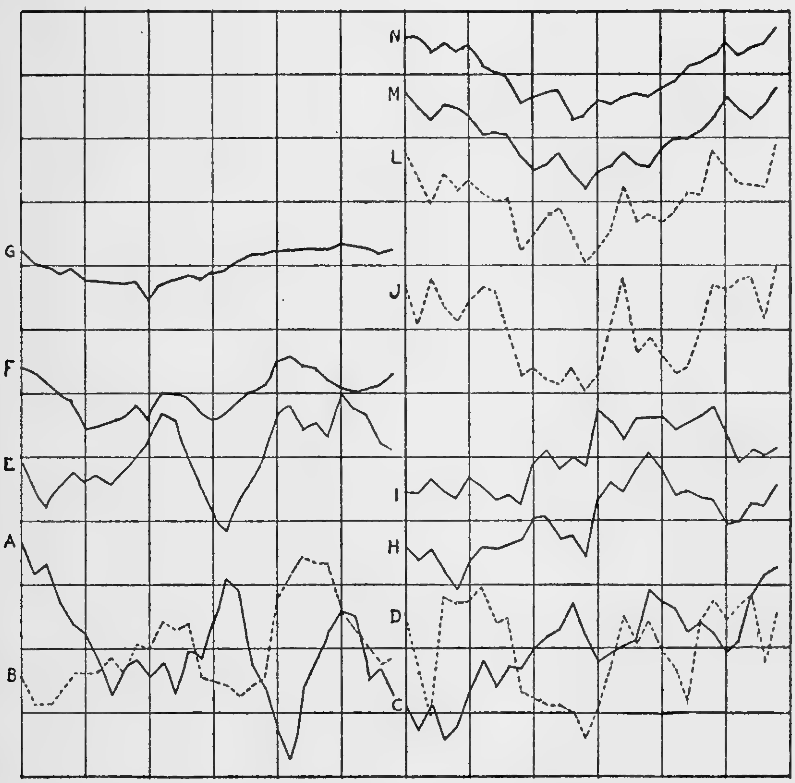


FIG. 10.—The $30\frac{1}{3}$-month periodicity in Peoria precipitation as modified by shorter periodicities, aliquot parts of $30\frac{1}{3}$ months. Left, Wolf numbers over 20; right, Wolf numbers below 20.

in full and dotted curves respectively. Treating a_1 first, curve A is what is found when the period of $\frac{45.5}{2} = 22\frac{3}{4}$ months is removed. A feeble period of $\frac{45.5}{5}$ months is then removed, yielding curve B. Though not altogether smooth, no other period seems clearly included in curve B. As only five repetitions of the $45\frac{1}{2}$-month period were

available in the original data, I think we should expect nothing smoother, for 21 other periods interfere with their own features, as well as $45\frac{1}{2}$ months. Turning to curve a_2 the periods of $\frac{45.5}{2}$ and $\frac{45.5}{3}$ are successively removed, as shown in the dotted curves C and D. Here, again, nothing more can be removed. I now shift curve B to 5 months later, and take the mean of it and curve D, yielding

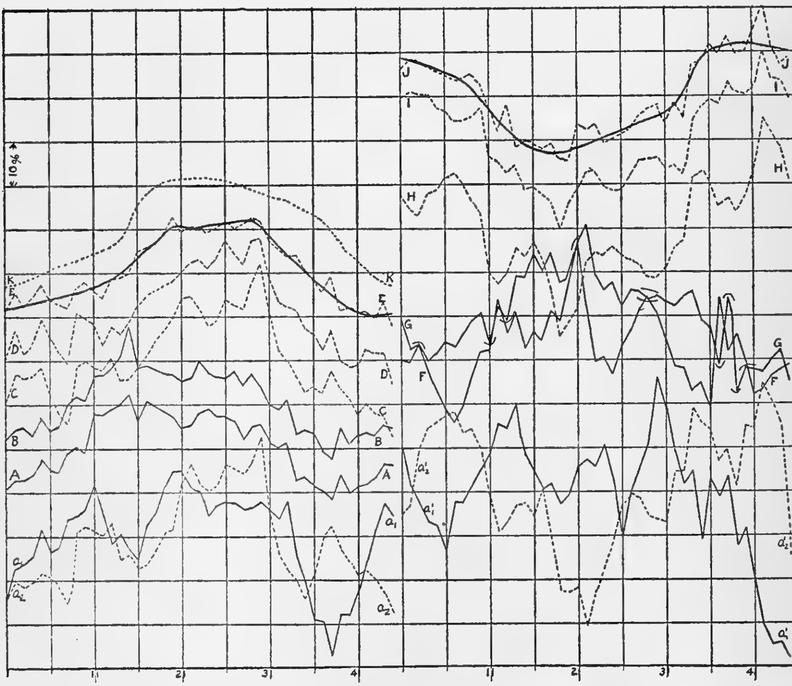


FIG. 11.—The $45\frac{1}{2}$-month periodicity in Peoria precipitation as modified by shorter periodicities, aliquot parts of $45\frac{1}{2}$ months. Left, Wolf numbers above 20; right, Wolf numbers below 20.

the dotted curve E, to represent the $45\frac{1}{2}$-month periodicity in precipitation at Peoria, Ill., 1856 to 1939, when Wolf sunspot numbers > 20. The heavy full curve smooths out the interferences by other periods, and the accidental errors, and shows an amplitude of 22 percent for the $45\frac{1}{2}$-month periodicity.[11]

[11] I felt some doubt at one time whether this procedure, of computing subordinate periods from mean values for long periods, would give approximately correct results. But I satisfied myself in two ways. First, since the later stages of my

Turning now to the times when Wolf numbers were < 20, the curves a_1^1 and a_2^1 on the right of figure 11 represent the mean results of only four intervals before, and four after 1900. I feel sure that no one, glancing at these two curves, would think that they really indicate a period of $45\frac{1}{2}$ months in Peoria precipitation! But on removing $\frac{45.5}{2}$ months from a_2^1, the curve F results. It indicates a period of $\frac{45.5}{5}$ months remaining. Removing this, we get curve G. (At several places in figure 11 I trace its course by guide lines.) Curve G is not smooth, but no subordinate periods are plainly seen. Indeed, from only four repetitions one could not expect a smooth curve, considering interferences from 21 other periods. Removing $\frac{45.5}{2}$ months from curve a_2^1, we have the dotted curve H, and from this $\frac{45.5}{5}$ months is removed, yielding curve I. This also is made irregular by lack of sufficient repetitions of the $45\frac{1}{2}$-month curve in the original data. Curve G is now shifted 20 months to the right and combined with curve I, yielding the dotted curve J. A heavy smooth curve is drawn to better represent the $45\frac{1}{2}$-month period in Peoria precipitation, for all times when Wolf numbers < 20, from 1856 to 1939. If the heavy smooth curve representing times when Wolf numbers < 20 is now displaced to the left 17 months, and superposed, as shown dotted at K over the heavy smooth curve representing Wolf numbers > 20, the differences found are small. However the curve for Wolf numbers < 20 has the amplitude of 25 percent of normal precipitation at Peoria, while the other has a range of only 22 percent.

From these reductions, shown graphically in figure 11, we find periods of $\frac{1}{6}$, $\frac{1}{12}$, $\frac{1}{18}$, and $\frac{1}{30}$ of $22\frac{3}{4}$ years. Many other examples might be given of overriding periods, which are aliquot submultiples of the periods of greater length, with which they are associated. But surely these three samples, which disclose periods of $\frac{1}{4}$, $\frac{1}{6}$, $\frac{1}{8}$, $\frac{1}{9}$,

tabulations are always made with *departures from the mean* of the long column representing a long period, half of the departures are above, and half below the mean. Hence, in making the tabulation for the subordinate period, though half of the values employed in the tabulation are larger than truly representative of the subordinate period, the other half are equally smaller than they should be. These excess and deficient parts nearly cancel, leaving the subordinate period approximately correct. When it is removed from the longer one, this longer curve also is approximately correct. As a check, however, I once drew a smooth curve touching all the low points of the longer curve and computed the subordinate period from differences between this smooth curve and the original. Comparing, there was no considerable difference from the characteristics of the subordinate curve when obtained in the usual way.

$\frac{1}{12}$, $\frac{1}{18}$, $\frac{1}{20}$, $\frac{1}{27}$, $\frac{1}{28}$, $\frac{1}{30}$ and $\frac{1}{63}$ of $22\frac{3}{4}$ years, together with the other lines of evidence presented above in Part 2, and the close accord between syntheses and events, shown by using 22 such periods to predict precipitation many years from base, as in figures 1 to 5 of Part 1, must be sufficient to justify my claim to the discovery of a numerous family of periodicities in weather elements. All, to within 1 percent, are exact submultiples of $22\frac{3}{4}$ years. Very long range general weather predictions have been and can be made, using them.

I feel that if meteorologists could accept these proofs, governments would feel justified in supporting similar studies of temperature and precipitation at numerous stations within their borders. From such studies maps of expected weather conditions for many years in advance could be drawn. Such maps, if found to give general conditions with reasonable approximation, would evidently be of great value for many industries. The only fly in the ointment seems to be that tremendous disturbances of the atmosphere, such as sometimes are caused by volcanoes, and also by profuse use of powerful bombs, in war and in tests, may spoil forecasts of this ambitious type.

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PERIODIC SOLAR VARIATION

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PERIODIC SOLAR VARIATION

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Many stars are variable, some intrinsically, others by reason of bodies interposing between them and us, as with the eclipsing variables. Our star, the sun, is rarely eclipsed. Astronomers question whether the sun's intrinsic variations are perceptible. I propose to offer observational evidence.

The great obstacle to such an investigation of our star, the sun, is the earth's atmosphere. It offers no such difficulty in measuring variations of the other stars, for the star to be investigated may be compared with many neighboring stars, whose rays suffer nearly the same atmospheric obstruction. Daylight sun drowns out all its neighboring stars.

The planets, which all shine by reflected sunlight, might indeed be compared with neighboring stars. But they are all too imperfect mirrors to yield highly accurate results on the sun's variation. We are therefore forced to make absolute determinations of intensity of the sun's rays, day after day, with proper allowances for the losses they suffer in passing through the atmosphere. Many scientists think it is impossible thus to achieve sufficient accuracy to determine the sun's small percentage variation.

For many years the Smithsonian Astrophysical Observatory has carried on measurements of the intensity of the sun's rays as they would be found at mean solar distance outside our atmosphere. This is called "the solar constant of radiation." The methods and results are described in detail in volumes 2 to 7 of the Annals of the Astrophysical Observatory. We shall not dwell on the methods here. The observations have been made daily, as far as possible, from mountains 6 to 10 thousand feet in elevation, in arid lands, from the year 1918 to the present time. Our stations have been in both hemispheres. Careful comparisons of the measures show no appreciable systematic differences between them, owing to the southern winter occurring in northern summertime. Automatically recorded measurements from balloons at 15 miles elevation show that the solar-constant values are

reasonable. That is to say, our estimates of atmospheric transmission are sound.

Since the total range of variation found in 10-day mean values of the measures of the solar constant only rarely exceeds 2 percent, and usually is less than 1 percent, scientists, well knowing the seriousness of the obstacle to accuracy presented by variable atmospheric transmission, very reasonably fear that we cannot certainly determine variations of the sun. It is therefore well to present at the outset the evidence on the accuracy of our solar-constant measures.

As stated in volume 6, page 163, of the Annals of the Astrophysical Observatory, a comparison has been made between very large numbers of pairs of daily solar-constant measurements, made thousands of miles apart, in opposite hemispheres, over a period of many years. It yields, from their differences, the result that the probable error of a well-observed solar-constant value, the mean of the results at two stations on a single day, is $\frac{0.164}{\sqrt{2}}$ percent, or $\frac{1}{8}$ percent.

In the work I am about to present on periods in solar variation, 20 out of 31 of the periodic tabulations (excluding 11 tables on a monthly basis, made upon periods of variation exceeding 20 months) comprise tables of 10-day means of the measurements at two or more stations.[1] These tables each contain from 10 to 100 repetitions of such 10-day means. Going back to daily observations, published in volumes 6 and 7 of the Annals, it will be found that most of the 10-day means are means of the average results of two or more stations over at least 4 days, sometimes even 10 days, and of one station during the remainder of the decade. Using the well-known rule that the probable error of the general mean is the probable error of the individual observation divided by the square root of the number of observations, we see that for two-thirds of the tabulations, and excessively so for the periods under 10 months, for which the number of columns of repetition is above 40, the probable error of the individual values in the final column of means is of the order of 1/60 of 1 percent or less. Hence readers should not be skeptical, when smoothly running curves of periodic variation are presented that have a range as small as 0.04 percent. From that minimum, the ranges to be presented in this paper rise to values for some periodic variations of 0.15 to 0.20 percent. In fact, all the periods, some 23 in number, used in my weather papers on precipitation and temperature at various cities, have ranges in solar variation exceeding 0.05 percent. As

[1] I shall deal with monthly data below.

for weather features, the ranges in precipitation found for these same individual periods run from 5 to 25 percent. Ranges in temperature for individual periods sometimes reach over 2° Fahrenheit.

In an earlier paper, "Periodicities in the Solar-Constant Measures" (Smithsonian Misc. Coll., vol. 117, No. 10, 1952), I used nearly all of the observed solar-constant values, from August 1920 to December 1950. This interval included the unique depression of the solar constant of about 5 percent, which was found in 1922 and 1923. It also included the widely varying values found from 1920 to 1922. In this present research I desired to obtain the highest attainable accuracy. Both in length and range I aimed to determine the best average values of periodic variations in solar radiation. I therefore purposely omitted those exceptional years, and began with September 1923, ending with December 1952.

There is a weightier reason than this improved selection of data for revising my former study of solar radiation. I have become more and more convinced, by my researches on precipitation and temperature, that a simple tabulation of a suspected period, in a long series of monthly or 10-day values, is unconvincing as to the reality of periodicity. For there is a large family of periods that have been found in various phenomena, all members of which are aliquot parts of $22\frac{3}{4}$ years. Not only does a long succession of monthly or 10-day means contain numerous members of this family, but the individual members, if segregated merely by simple tabulations, each contains, in its mean expressions, several shorter periods which are aliquot parts of the period being investigated.

Unless these shorter periods are removed, the mean expression of the desired period is so marred in form as to be unconvincing. No elimination of these overriding shorter periods, aliquot parts of the periods determined, was done in the publication just cited.

In the present publication I shall disclose a considerable number of new members of the family, found overriding known periods, and all integrally related to $22\frac{3}{4}$ years. Many of these new periods are so short as to be better expressed in days than in months. They include some of the periods discovered in basal pulse rates by my friend Dr. F. P. Marshall.

After a short statement regarding the solar-constant data, specimens of the treatment of it will follow, and after that the conclusions reached will be given in tables and graphs.

In my former publication (cited above), I gave, in table 4 in the appendix, a list of solar-constant values of the years 1920-1950. For convenience of tabulation these values were given in the form of

departures from 1.90 calories per square centimeter per minute. They were given, not in calories, but in fractions of our mean values of the solar constant, which is 1.946 calories per square centimeter per minute. Thus an observed value, for instance 1.950 calories, would be computed for tabulation as a departure, $\frac{1.950-1.900}{1.946}$, or 2.58 percent of the mean solar constant. To save printing, the decimal point is omitted in the table. When the range of a period in solar variation is found (if, for example, it is 7 on this scale) we know at once that its range is 0.07 percent of the mean solar constant. In table 1 of the present paper I add to the former table mentioned above the departures in solar-constant values from volume 7 of the Annals, which represent the years 1951 and 1952.

As I said above, comparisons of daily solar-constant measures, made in different hemispheres over many years, show that they go along together without systematic departures. Their accidental departures indicate a daily probable error of only $\frac{1}{8}$ percent when two stations cooperate. It is not material to our investigation of *solar variation* that our results should be expressed on precisely the true scale of heat units. Hence, though interesting, it is not disturbing that our accepted mean solar-constant value differs from the new determination of the solar constant by F. S. Johnson.[2] He used, in part, recent rocket observations, and his result is 2.00 ± 0.04 calories. It differs by 2.7 percent from ours, which is 1.946 calories. But our work on *solar variation* is not thereby prejudiced.

I now proceed to illustrate, by examples of a short and a long period in solar variation, the work presented. For the short period I take 7 months, which is $1/39 \times 273$ months. By tabulations and graphs, this 7-month period and its superriders will be given in considerable detail. For the long period I take $68\frac{1}{4}$ months. To save printing, the $68\frac{1}{4}$-month period will be given mainly by graphs. The method for it will have been apparent from the treatment of the 7-month period.

Table 2 gives the means of three groups of tabulations with 21 10-day mean values in each group, making an average 7-month period. They therefore summarize 51 repetitions. They include, respectively, 17 repetitions covering the interval September 1923 to December 1932; 17 repetitions January 1933 to November 1942; and 17 repetitions December 1942 to October 1952. The next step with each group is to compute the average march of thirds of the mean summaries. The justification for this will be apparent from the triple

[2] Journ. Meteorol., vol. 11, No. 6, December 1954.

TABLE 1.—*Solar-radiation changes, 1951-1952*
(A continuation of table 4 of Smithsonian Misc. Coll., vol. 117, No. 10, Publ. 4088)

Year	Month	Decade	Year	No.	Value	Mean No.	Year	Month	Decade	Year	No.	Value	Mean No.
5	1	I	1	1096	224		5	1	I	2	1132	211	
		II		97	315	260			II		33	268	247
	—	III		98	240			—	III		34	263	
5	2	I	1	99	257		5	2	I	2	35	195	
		II		1100	232	272			II		36	206	210
	—	III		01	327			—	III		37	228	
5	3	I	1	02	292		5	3	I	2	38	173	
		II		03	280	283			II		39	206	190
	—	III		04	276			—	III		40	189	
5	4	I	1	05	213		5	4	I	2	41	236	
		II		06	223	224			II		42	227	230
	—	III		07	235			—	III		43	222	
5	5	I	1	08	236		5	5	I	2	44	221	
		II		09	182	212			II		45	225	243
	—	III		10	219			—	III		46	282	
5	6	I	1	11	212		5	6	I	2	47	230	
		II		12	202	221			II		48	251	243
	—	III		13	248			—	III		49	244	
5	7	I	1	14	244		5	7	I	2	50	200	
		II		15	248	243			II		51	202	209
	—	III		16	237			—	III		52	226	
5	8	I	1	17	228		5	8	I	2	53	237	
		II		18	256	253			II		54	217	225
	—	III		19	276			—	III		55	220	
5	9	I	1	20	271		5	9	I	2	56	191	
		II		21	238	240			II		57	239	214
	—	III		22	210			—	III		58	212	
5	10	I	1	23	229		5	10	I	2	59	222	
		II		24	220	227			II		60	231	223
	—	III		25	232			—	III		61	209	
5	11	I	1	26	245		5	11	I	2	62	209	
		II		27	199	219			II		63	216	209
	—	III		28	212			—	III		64	202	
5	12	I	1	29	244		5	12	I	2	65	253	
		II		30	225	235			II		66	229	244
5	—	III	1	1131	236		5	—	III	2	1167	251	

maximum forms of curves in figure 1. The curves A_1, A_2, A_3 are the summaries, and the curves B_1, B_2, B_3 the mean forms of the periods of one-third of 7 months. Subtracting the latter from the former leaves C_1, C_2, C_3, which are the 7-month summaries deprived of the periodicities $1/117 \times 22\frac{3}{4}$ years. The results are tabulated in column 3 of table 2. We now perceive in curves C_1, C_2, C_3 a period of one-fourth their length. Removing it, as before, we obtain curves D_1, D_2, D_3, and columns 4 and 5, table 2. There is now seen, indistinctly it is true, except in D_1, a period of one-seventh of 7 months. Removing it as before, the curves E_1, E_2, E_3 result, and also columns 6 and 7 of table 2. No other superriders being seen in curves E_1, E_2, E_3, and all three of these curves being in the same phase and of similar forms, we conclude that there is no further correction required to the period 7.0 months. The three curves E_1, E_2, E_3, are therefore combined into the general mean curve F and column 8 of table 2. So there is clearly shown a period of exactly 7 months ($1/39 \times 273$ months) in solar variation. The 7-month period has a range of 0.08 percent of the solar constant. In association with it there are discovered three periods, 1/117, 1/156, and 1/273 of $22\frac{3}{4}$ years, having lengths of $2\frac{1}{3}$, $1\frac{3}{4}$, and 1 month, and ranges of about 0.06, 0.04, and 0.02 percent of the solar constant. The last of these three periods is perhaps doubtful, both on account of its small range, and of the divergence of phases in the three determinations of it. The other two superriders seem well determined, having similar forms and nearly similar phases and ranges in the three determinations. These superriders are, to be sure, less strongly developed in range in the middle curves than in the first and third sets, but the phases are nearly alike in all three.

Seven months in days is $7/12 \times 365.2564$ days, or 213.07 days. It is therefore interesting to note that, quite independently, my friend Dr. F. P. Marshall found a period of 212 days in a graph of 3 years of daily basal pulse rates. Dr. Marshall also found more than a dozen shorter periods, all aliquot parts of 212 days. Several of these periods I now find, as just said, to be also solar. It would seem to be interesting to physiologists to know that basal pulse rates are found to present regular periodic variations agreeing, within less than 1 percent, with periods found in solar variation. As my studies of weather elements show,[3] the family of periods that relate integrally to 273 months is also active in the control of temperature and precipitation. It may therefore well be that solar variation affects weather, and weather affects basal pulse rate.

[3] See Smithsonian Misc. Coll., vol. 128, No. 3, Publ. 4211, Apr. 28, 1955.

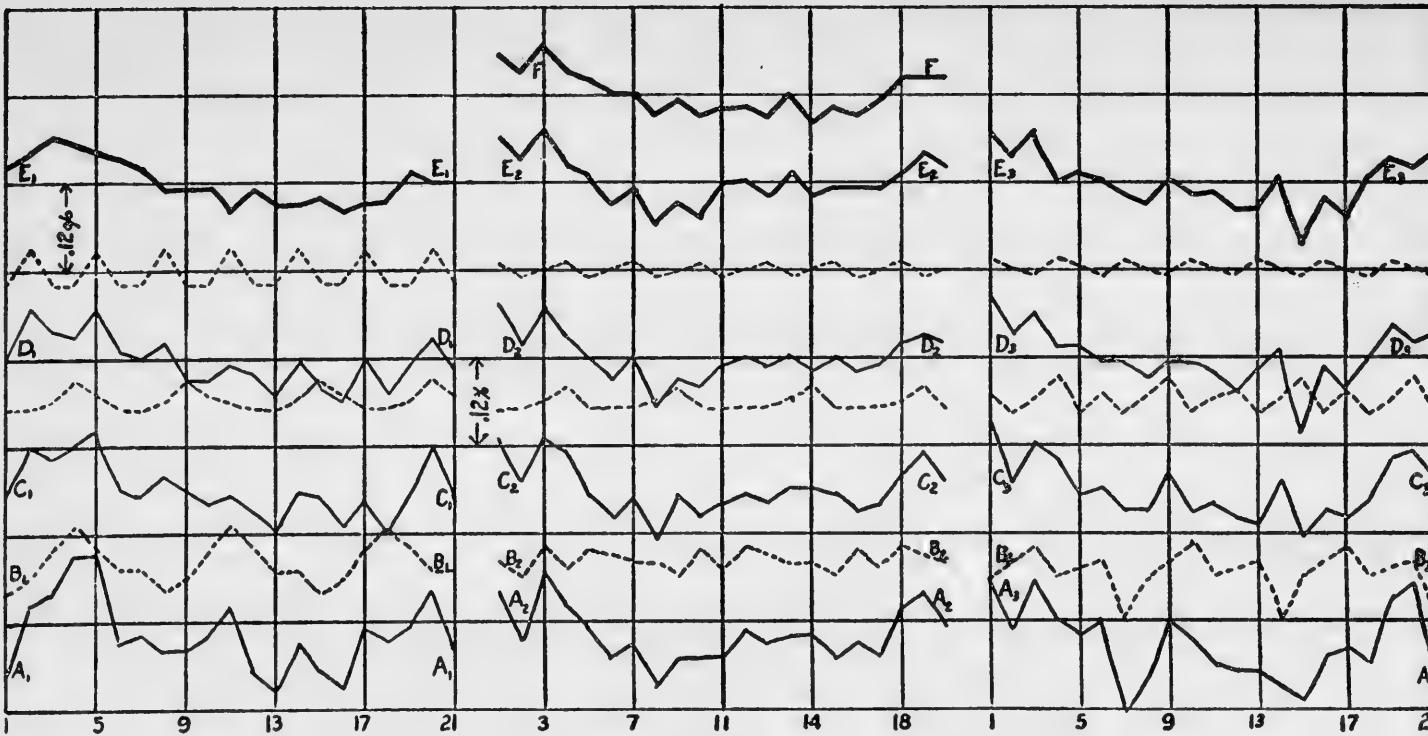

FIG. 1.—Three 10-year successive determinations of the 7.0-month period in solar variation, as cleared of subordinate interfering integrally related periods.

TABLE 2.—*The 7-month period*

From 10-day means

No.	1	2	3	4	5	6	7	8
1	225	226	−1	−1	0	−2	+2	+5
2	234	228	+6	−1	+7	+3	+4	+3
3	236	232	+4	0	+4	−2	+6	+7
4	241	235	+6	+3	+3	−2	+5	+3
5	240	232	+8	+1	+7	+3	+4	+2
6	229	229	0	−1	+1	−2	+3	0
7	230	229	+1	−1	0	−2	+2	0
8	228	226	+2	0	+2	+3	−1	−3
9	228	228	0	+3	−3	−2	−1	−1
10	230	232	−2	+1	−3	−2	−1	−3
11	234	235	−1	0	−1	+3	−4	−2
12	225	232	−7	−1	−2	−2	−1	−2
13	223	229	−6	−1	−5	−2	−3	−3
14	229	229	0	0	0	+3	−3	0
15	225	226	−1	+3	−4	−2	−2	−4
16	223	228	−5	+1	−6	−2	−4	−2
17	231	232	−1	−1	0	+3	−3	−3
18	229	235	−6	−1	−5	−2	−3	−1
19	231	232	−1	0	−1	−2	+1	+2
20	235	229	+6	+3	+3	+3	0	+2
21	228	229	−1	+1	−2	+2	0	+2
22	246	240	+6	−1	+7	+1	+6	..
23	239	238	+1	−1	+2	−1	+3	..
24	249	242	+7	0	+7	0	+7	..
25	244	239	+5	+2	+3	+1	+2	..
26	241	242	−1	−1	0	−1	+1	..
27	237	241	−4	−1	−3	0	−3	..
28	239	240	−1	−1	0	+1	−1	..
29	233	240	−7	0	−7	−1	−6	..
30	237	238	−1	+2	−3	0	−3	..
31	237	242	−5	−1	−4	+1	−5	..
32	237	239	−2	−1	−1	−1	0	..
33	241	242	−1	−1	0	0	0	..
34	239	241	−2	−1	−1	+1	−2	..
35	240	240	0	0	0	−1	+1	..
36	240	240	0	+2	−2	0	−2	..
37	237	238	−1	−1	0	+1	−1	..
38	239	242	−3	−1	−2	−1	−1	..
39	237	239	−2	−1	−1	0	−1	..
40	244	242	+2	0	+2	+1	+1	..
41	246	241	+5	+2	+3	−1	+4	..
42	241	240	+1	−1	+2	0	+2	..
43	247	238	+9	+1	+8	+1	+7	..
44	241	240	+1	−2	+3	0	+3	..
45	248	242	+6	0	+6	−1	+7	..
46	242	238	+4	+3	+1	+1	0	..

TABLE 2.—Continued

47	238	239	−1	−2	+1	0	+1	..
48	240	240	0	+1	−1	−1	0	..
49	229	232	−3	−2	−1	+1	−2	..
50	235	238	−3	0	−3	0	−3	..
51	242	240	+2	+3	−1	−1	0	..
52	239	242	−3	−2	−1	+1	−2	..
53	236	238	−2	0	−2	0	−2	..
54	235	239	−4	+1	−5	−1	−4	..
55	235	240	−5	−2	−3	+1	−4	..
56	233	232	+1	0	+1	0	+1	..
57	231	238	−7	+3	−10	−1	−9	..
58	237	240	−3	−2	−1	+1	−2	..
59	238	242	−4	+1	−5	0	−5	..
60	236	238	−2	−2	0	−1	+1	..
61	243	239	+4	0	+4	+1	+3	..
62	245	240	+5	+3	+2	0	+2	..
63	233	232	+1	−2	+3	−1	+4	..

Turning to the $68\frac{1}{4}$-month period, instead of 51 repetitions of it, as in the tabulation of the 7-month period, there are only 5. Yet, as monthly means are used instead of 10-day means, the individual values are probably more precise in proportion to $\sqrt{3}$. Combining these two considerations, the probable error of the mean values in the $68\frac{1}{4}$-month tabulation is $\sqrt{\frac{51}{5\times 3}}=1.8$ times as great as of those in curve F of figure 1. Hence we are not to expect as smooth a curve for $68\frac{1}{4}$ months as curve F of the 7-month period. But on the other hand, as we shall see, the range of the $68\frac{1}{4}$-month solar period is nearly three times as great as that of the 7-month period. There is therefore no difficulty in recognizing the $68\frac{1}{4}$ period as well evidenced.

In figure 2, AA is the direct mean of five repetitions of the monthly values composing a period of $68\frac{1}{4}$ months. The curve AA is very rough, but shows some indication of a superrider of $68\frac{1}{4}\div 3$, or $22\frac{3}{4}$ months. Extracting this short period, curve BB results. This curve discloses a period of $\frac{1}{2}\times 68\frac{1}{4}$ or $34\frac{1}{8}$ months. Extracting it, curve CC results. This shows very plainly a period of $1/7\times 68\frac{1}{4}$ months. Extracting it, curve DD results. Here, somewhat less distinctly, a period of $1/11$ of $68\frac{1}{4}$ months is seen. Extracting it, curve EE results. Here, by careful analysis, a period of $1/19\times 68\frac{1}{4}$ months is found. Removing it, there remains curve FF, which, though it may contain shorter subperiods, is smooth enough to plainly exhibit the trend of the $68\frac{1}{4}$-month period, originally so much obscured in curve AA. The smooth curve GG has a range of 0.18 percent of the solar constant.

Having shown by these two figures examples of the smoothing of the solar-radiation periodicities by removing overriding shorter periodicities integrally related, I add that these two examples are by no means exceptional. Twenty others as convincing might be similarly presented. My ignorance of hydrodynamics prevents me from suggesting a theory to explain why this large family of integrally related periods occurs in solar radiation. Surely, however, it is a problem that deserves the attention of experts in stellar theory, for the sun is a convenient laboratory for stellar investigations.

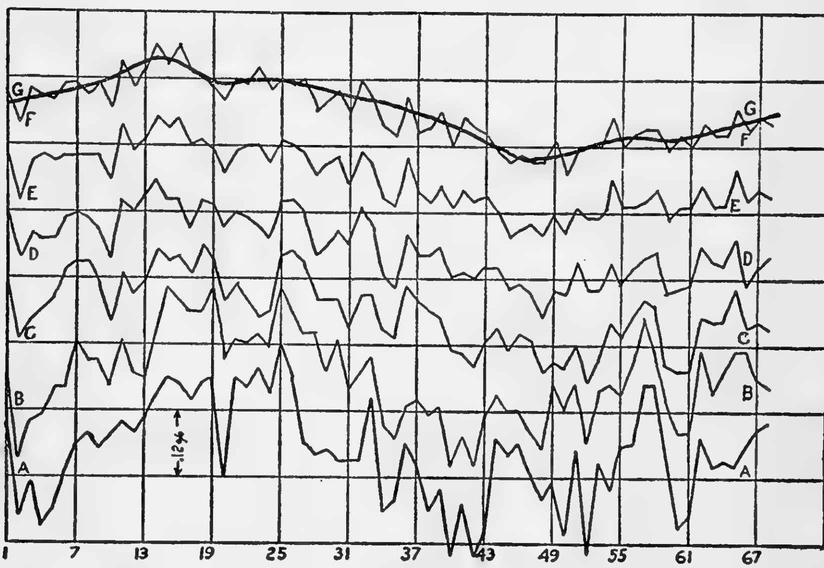

FIG. 2.—The $68\frac{1}{4}$-month period in solar variation as cleared of subordinate interfering integrally related periods.

Some critics, incredulous of the causation of weather changes by such small percentages in solar radiation, may be inclined to turn the phenomena about. They may suggest that some *terrestrial* atmospheric condition sets up the family of periods first in weather elements. Then they may suggest that these atmospheric changes produce, by our inability to entirely eliminate such influences, the observed tiny percentage periodic fluctuations in solar-constant measures. Such an explanation seems untenable to me. For the solar-constant periodicities go on with perfect regularity of phases over long periods of years, as table 2 and figure 1 show. This is so, despite the measurements being made in two hemispheres. The terrestrial periodicities, on the other hand, are altered in phases (a) with the season of the

years; (b) with the prevalence of sunspots; (c) with the locality; and (d) with changes in the occupation of the land surface. Such phase-alterable agencies in the atmosphere could not, it seems to me, possibly produce periods of *unalterable* phases in solar-constant measures.

The fact remains, as yet unexplained, that both the sun's radiation and the elements of the weather are subject to variations in identical families of numerous periods. All are to within 1 percent exact aliquot parts of 273 months. It would be incredible if they are not associated in their cause. Furthermore, though over 20 of the solar variations range only from 0.05 to 0.21 percent of the solar constant, the corresponding periods in precipitation at St. Louis, Peoria, and Albany range from 5 to 25 percent of normal precipitation. So the percentage range in precipitation is a hundred times the range in solar variation. Here is indeed a paradox worthy of explanation.

I now give in table 3 a summary of all the periods discovered thus far in solar-constant measures, their ranges, and the range of corresponding periods in precipitation at St. Louis. Over 20 of the solar periods, identical with those I have used in weather studies, have been cleared of superriding periods, as shown among the total of 26 assembled in figure 3, and are well determined to be real. The other solar periods given in table 3 are the superriding periods which have been cleared away from the forms of periods shown in figure 3. They also are real, but their ranges and forms are only roughly estimated from the tabulations. In figure 3 the numbers attached indicate how many times the period shown will repeat in 273 months.

In table 3, line 1 gives the number of times periods of length given in line 2 will repeat in 273 months. In line 3 the values, called *S*, give the ranges of these periods in percentage of 1.946 calories per square centimeter per minute. Line 4, called *L*, gives the ranges of identical periods in percentages of normal precipitation at St. Louis, Mo. Line 5 and the following lines give the ratio numbers and approximate percentages of 1.946 calories of superriding periodicities found associated with periods in line 2.

Details regarding the period of 273 months are omitted in table 3 for lack of repeating data. I tested every submultiple of it up to 21, then kept on with only those periods that were used in weather studies. In all, 31 periods were investigated. Those marked with asterisks were found to differ slightly from exact integral submultiples of 273 months, when their lengths were adjusted to best fit the observations of the solar constant. The periods with ratio values, 13, 16, 17, 19, 20, and 26 proved to have such small amplitudes as to be negligible.

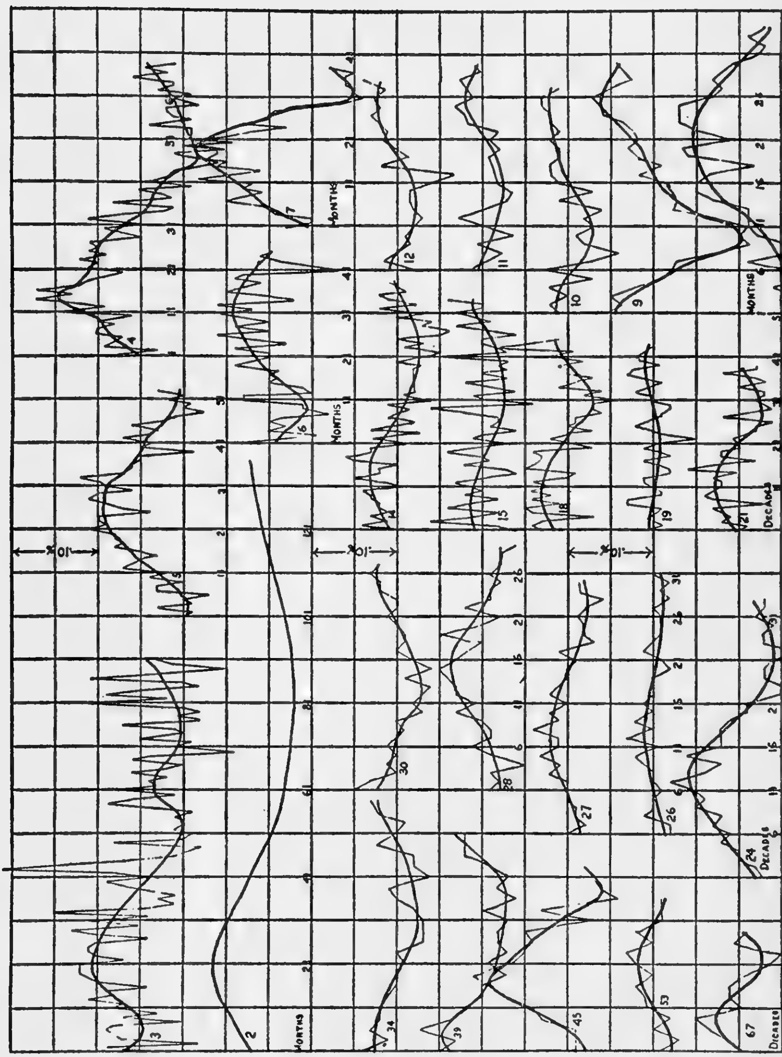

FIG. 3.—Twenty-six periods in solar variation, ranging from 4.08 months to 136½ months, as cleared of subordinate interfering integrally related periods.

TABLE 3.—*Summary of solar periods*

Ratio:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Period:	273	136.5	91.0	68.25	54.6	45.5	39.0	34.12	30.33	27.3	24.82	22.75	21.0	19.5	18.2	17.06
Range S:	...	0.09	0.11	0.18	0.09	0.09	0.21	0.12	0.17	0.06	0.05	0.05	0.03	0.07	0.05	0.0
Range L:	...	.....	13	13	0	8	23	21	15	19	18	17	....	....	....	....
Riders and Ranges S:	...	4	9	8	10	12	21	24	36	30	22	24	26	28	30	32
	...	0.18	0.20	0.14	0.08	0.09	0.08	0.09	0.04	0.04	0.06	0.08	0.03	0.02	0.03	0.12
		8	18	12	15	18	28	40	45		33		39	42	45	
		0.15	0.04	0.11	0.06	0.05	0.05	0.02	0.05		0.03		0.10	0.06	0.06	
			21	28	20		35	48	54		55		52	112		
			0.04	0.08	0.02		0.03	0.02	0.06		0.02		0.05	0.02		
			24	44	35				63				65	154		
			0.09	0.05	0.04				0.06				0.03	0.02		
			33	76	45											
			0.04	0.02	0.11											
			39													
			0.07													
			66													
			0.04													

TABLE 3.—Continued

Ratio:	17	18	19	20	21*	24*	26	27	28	30	34*	39	45	53	67
Period:	16.06	15.07	14.37	13.65	13.1	11.39	10.5	10.11	9.75	9.1	8.1	7.0	6.07	5.15	4.07
Range S:	0.00	0.08	0.02	0.00	0.07	0.11	0.03	0.05	0.07	0.06	0.06	0.08	0.13	0.04	0.08
Range L:	....	26	....	18	10	15	12	10	23	18	12	9	8	7	4
Riders and Ranges S:	....	54	38	....	42	72	52	54	84	60	102	117	....	106	134
		0.07	0.02		0.08	0.05	0.08	0.08	0.03	0.06	0.05	0.08		0.03	0.04
		72	57		105	168	78	81	112	90	136	156			
		0.03	0.05		0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.04			
		180	76		147		130	105			170	273			
		0.03	0.05		0.04		0.03	0.04			0.04	0.02			
			95				234								
			0.03				0.04								
			209												
			0.02												

Only two of these, ratio values 20 and 26, have ever been included in my weather investigations.

Besides the 25 periods well evidenced among the 31 especially sought for in solar variation, the following 14 with ranges of 0.05 percent or more were found in association with them:

Ratio	15	22	32	42	44	52	54	57
Range	0.06	0.08	0.08	0.08	0.05	0.08	0.08	0.05
Ratio	60	63	72	76	102	117		
Range	0.06	0.06	0.05	0.05	0.05	0.06		

In addition to all these, the following 27 periods, with ranges of 0.04 percent or less, were removed from the 30 periods specially investigated, being superriders:

Ratios	26, 33, 35, 40, 48, 65, 66, 78, 81, 84, 90, 95, 105, 106, 112,
Ratios	120, 134, 136, 144, 154, 156, 168, 170, 180, 209, 234, 273.

Thus (omitting duplicates) in all 64 periods, integral submultiples of 273 months were found with various strengths of evidence in the variation of the solar-constant measures. The most convincing evidences of the reality of these periodic variations in solar radiation are found: First, in the smooth runs of the curves in figures 1, 2, 3, resulting from the elimination of the 41 periods just enumerated. Second, the cumulative effect upon the mind of finding in solar variation 31 smooth periodicities, all aliquot parts of 273 months, to within 1 percent. Third, in the fact that 20 of the especially sought and discovered periods in solar variations are found identically, in large percentage ranges, in weather features. In my future weather tabulations, the lengths of the periods found in solar variation will be followed exactly, not merely approximately, as heretofore. The fairly large solar periodicities, 14, 15, 22, 32, 42, 52, and 54, not heretofore used in weather, will be tested as possible weather periods. Numbers 20 and 26, hitherto used, will perhaps be omitted. Number 10 is sometimes found strong in weather features, and sometimes only its half, 27.3 months, appears.

In figure 3, the curves are designated by the ratio numbers given in table 3. All the curves in figure 3 are drawn to the same scale of ordinates, and that scale is indicated by three scales of 0.10 percent each. Three scales of abscissae are used, and these are indicated in figure 3. The first group of periods, 34 to 67, has the most open scale. The two groups 24 to 30 and 14 to 21 have identical scales, less open than used in the group 34 to 67. All the longer periods, 2 to 12 inclusive, are given in months instead of decades. Of these, the

group 8 to 12 employs for months the same scale that is used for the decades in groups 24 to 30 and 14 to 21. All the remaining curves, 2 to 7, are plotted on a closer scale in abscissae as indicated in figure 3.

All the curves in figure 3 are based on September 1923 as zero. The decade 10-day means begin with September 5, and the monthly means, used in plots 2 to 12, begin with September 15, 1923. Inasmuch as all the curves in figure 3 depend for their forms and ranges on *all* the Smithsonian solar-constant work from September 1923 to December 1952, a synthesis of them all should represent the total monthly variation of the sun during that epoch, if the monthly solar variation is altogether composed of the family of periodicities integrally related to 273 months.[4]

I have made such a synthesis from September 1923 to December 1935, and present it in figure 4. Except for periods 2 and 3, I used ragged curves of figure 3, not the smooth ones. The dotted curve in figure 4 is my synthesis, and the heavy full curve represents the monthly solar-constant means observed. Except in 1924 and 1925, there is as fair an agreement as the probable error of observation would lead to expect.

Regarding 1924 and 1925, in chapter 3, pages 33 to 42, volume 6 of the Annals of the Astrophysical Observatory, there are detailed the difficulties found in preserving a sound and constant scale of solar-constant measurements. On pages 40 to 42 is told in detail how the results of other cooperating observatories were made to fit with the scale of results of Montezuma, which we considered the best. Several changes of the scale of measurement at Harqua Hala were made in 1924 and 1925 to harmonize with Montezuma. Besides these more or less arbitrary changes, it is related on pages 33 to 35 that a defective process of reduction of observations was introduced in 1923. Its erroneous character was not discovered till 1936. A new and correct method was then devised. In order to correct the results obtained from 1923 to 1936, the observers at the field stations were required to remeasure the bolographic plates of that interval in order to obtain the data needed in the new method devised in 1936. But parts of the earlier years 1924 and 1925 could not be thus salvaged. Some results for those years were therefore recomputed from the observations in the best way possible with data available, but they may not be as good as the work preceding and following. Accordingly I do not regard the heavy curve in 1924 and 1925 as being of

[4] It is, of course, well known that day-to-day short ups and downs occur in solar variation, and are associated with weather, and with ionospheric fluctuations.

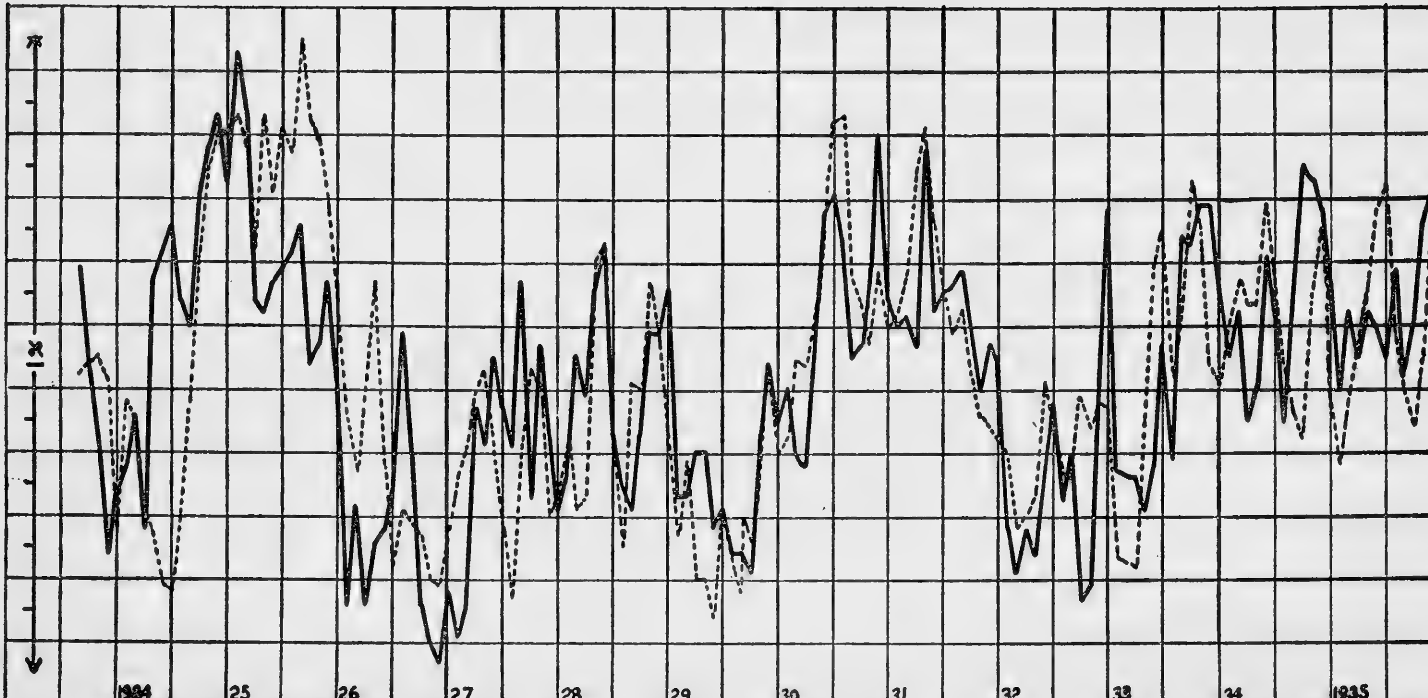

Fig. 4.—Synthetic combination of 31 periods in solar variation, as shown unsmoothed in figure 3, and compared with observed monthly solar-constant values of years 1923 to 1935. Full line, observed; dotted line, synthetic.

much weight. Indeed I regard the dotted one as best for those years, since the dotted curve fits so well elsewhere.

Obtaining differences between synthesis and observation, the following are mean values of deviations in percentages of the solar-constant result:

Epoch	1923 Sept. to 1927 Apr.	1927 May to 1929 Nov.	1923 Sept. to 1929 Nov.
Mean percent ...	±0.18	±0.11	±0.15
Epoch	1929 Dec. to 1932 Sept.	1932 Oct. to 1935 Dec.	1929 Dec. to 1935 Dec.
Mean percent ...	±0.09	±0.15	±0.12

To reach this close agreement between synthesis and observation, not only are the main trends in solar variation followed in unison, but most of the short-period variable features of observation are seen also in the synthesis. Such good agreement over a span of 12 years seems to warrant the belief that a synthesis over the 23-year span, 1900 to 1923, will give a trustworthy view of the solar variation during that interval. Accordingly I have made such a synthesis, and give it graphically in figure 5.

Some critics might be inclined to say that the agreement of synthesis with observation from 1923 to 1935 is no warrant for the value of a synthesis from 1900 to 1923, for, they may say, the features of the 31 periods used were based in considerable part on the observations of 1923 to 1935. Hence the synthesis within those years *should* agree with those observations. But if one takes any three years, as July 1929 to July 1932, the observations of those years could have had but 10 percent influence on the features of the 31 periods derived from 30 years of observation. Yet the average difference between synthesis and event in that interval is but 0.062 percent of the solar constant. The coefficient of correlation between synthesis and event during that interval is 90±5 percent. Is not this satisfactory indication that a synthesis of the 31 periodicities at any epoch is apt to be nearly true to fact?

Holding this conviction, I offer figure 5 as probably a good representation of the variation of the solar radiation for most of the first two decades of the twentieth century. Of course, if there occurred some other extraordinary variations of the sun, such as depressed the solar-constant measures by 5 percent in 1922, there may have been other changes outside of those represented in figure 5.

In figure 4 the solar-constant values began with September 1923. Counting back 273 months brings us to December 1900. All the periods being exact submultiples of 273 months, it follows that, so far as these periods comprise all the elements of change in solar radia-

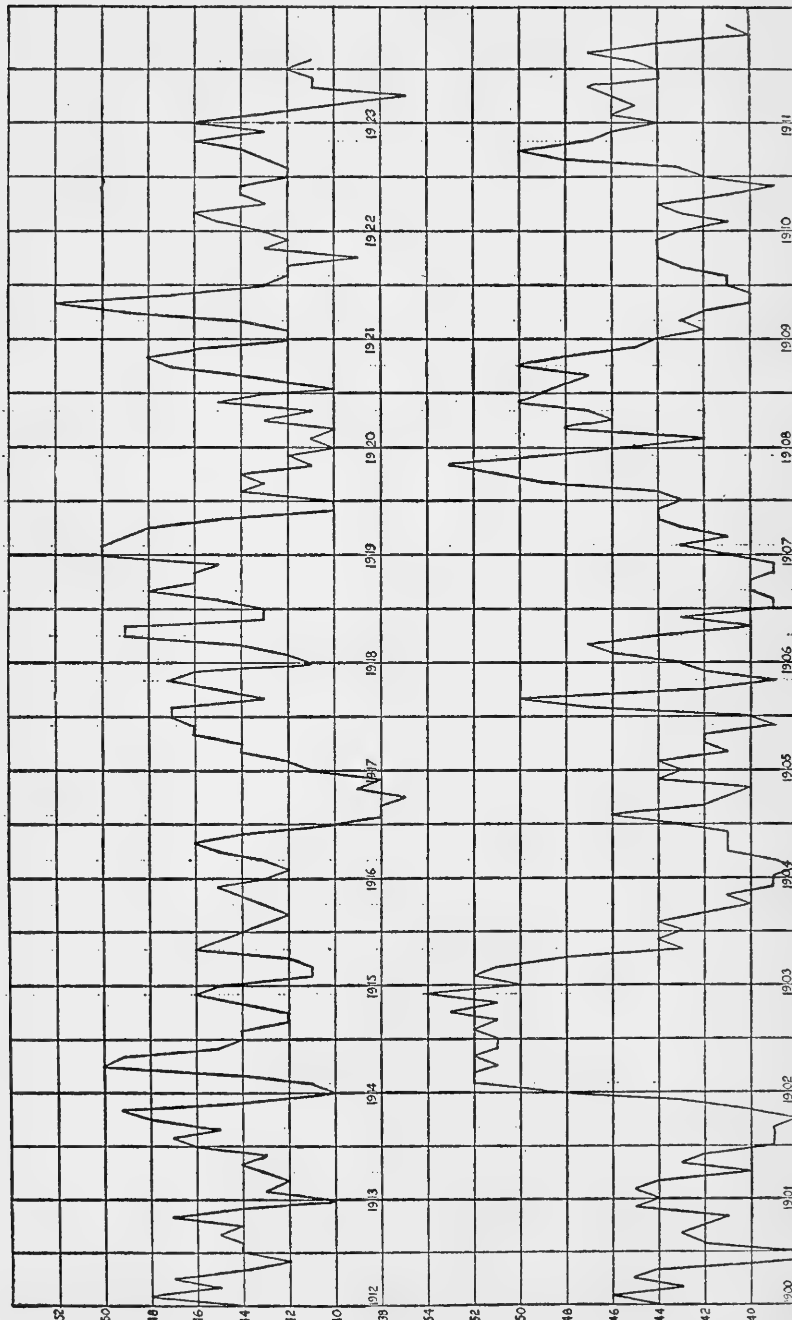

FIG. 5.—Synthetic reproduction of solar variation (unobserved) 1900 to 1923.

tion, the solar-constant values beginning with December 1900 will be the same as those beginning September 1923. In my recent paper on precipitation at St. Louis, Mo. (Smithsonian Misc. Coll., vol. 128, No. 3, 1955), I showed that synthesis by 22 periods, identical with 22 periods in solar variation, represented the precipitation at St. Louis well for 70 out of 100 years. The other 30 years appeared to be disturbed by great volcanic eruptions and great wars.

But it does not follow that, apart from these cataclysms, the weather, though controlled by solar variation, should repeat in 273-month cycles. For the quality of the atmosphere changes (a) with the time of the year; (b) with the prevalence of sunspots; (c) with the change of population, of forestation, and other variable features of the locality. Changes in the quality of the atmosphere alter the phases of weather responses to solar periods. Hence it is that, even apart from cataclysmic events, the weather only roughly repeats itself at intervals of 273 months. For 273 months is not commensurable with 12 months, and sunspot frequency is not sharply periodic at $11\frac{3}{8}$ years. Hence two variable agents, (a) and (b) above, somewhat confuse the tendency toward regular weather cycles of $22\frac{3}{4}$ years. The element (c) above, is quite unpredictable in its effect on the weather.

SUMMARY

Reference is made to 30 years of daily measurements of the solar constant of radiation, at a plurality of stations on arid mountains, 6,000 to 10,000 feet in altitude, and in both hemispheres. Comparison of many pairs of northern and southern daily results give a probable error of $\frac{1}{8}$ percent. Tabulations containing 30 to 100 repetitions of 10-day mean results are therefore subject to mean probable error of less than 1/60 percent.

A family of regular periods in solar variation is disclosed, containing 64 members, all, to within 1 percent, exact submultiples of 273 months. Many members of this family are also found in temperature and precipitation at several cities in the United States. In solar variation, ranges from 0.05 to 0.21 percent are found in over 20 of these periods which figure in weather. In the precipitation at St. Louis, Mo., these identical 20 and more periods have ranges from 5 to 25 percent.

Dr. F. P. Marshall found a period of 212 days, and also more than a dozen submultiples of it, in basal pulse rates. Seven months, a solar and weather period, is nearly the same, 213.07 days. A period published by the author in 1949, found in the weather of Washington and

New York as 6.6485 days, is very near 6.6476 days, which is $1/1250 \times 365.2546 \times 22\frac{3}{4}$.

I have presented graphs and tables showing solar periods and how interference by periods aliquotly related to them is removed. With such clearance, the total monthly mean solar constant is synthesized from 31 periods, and compared with mean observation. Close agreement is found, with an average deviation over 3 years of 0.062 percent, and correlation of 90 ± 5 percent.

One graph gives synthesized solar-constant monthly values, 1900 to 1923. It is stated that, apart from the unusual, the solar constant should repeat at intervals of 273 months in the monthly means. I showed 20 years ago that daily trends in the solar constant are closely correlated with weather trends, and later showed them correlated with ionospheric data. Monthly weather features should not closely repeat at intervals of 273 months, because of phase changes of weather periods, due to atmospheric changes.

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REVISION OF SOME RECENT FORAMINIFERAL GENERA

(WITH FOUR PLATES)

BY

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AND

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INTRODUCTION

For the past few years we have been restudying the genotype species of Foraminifera, with the aim of establishing a firmer basis for the taxonomy and classification of Foraminifera. As some of the early illustrations were quite generalized or inaccurate and the type specimens had not since been restudied, this reexamination is of extreme importance. As a result of it, some supposedly well-known genera are found to be synonymous with others and quite unlike what was commonly referred to them.

We are therefore here redescribing various genera of Recent Foraminifera, basing these diagnoses upon the type species, so that they may be better understood. Twenty-three Recent genera of Foraminifera are here described, for which ten generic diagnoses are emended, three genera are suppressed as being synonymous, and four new genera, one new species, and one new family are proposed.

Under each generic description which follows we have given the original reference, listed the type species, and how and when it was designated, given a generic diagnosis, as based upon the type species and in some cases an emendation of the original diagnosis, the location of the types (here again referring only to the type species), and a discussion of the various problems in taxonomy and morphology of the particular genus concerned, and in certain instances the reasons for the suppression of the generic name.

In the descriptive section of this paper and in the plate explanations

we have used the abbreviations U.S.N.M. for the U. S. National Museum, Washington, D. C., B.M.N.H. for the British Museum (Natural History), London, and M.N.H.N. for the Muséum National d'Histoire Naturelle, Paris, as nearly every type specimen figured and discussed was from one of these institutions.

ACKNOWLEDGMENTS

We have for the past few years been restudying all type species of genera available in this country or obtainable by loan or exchange from other countries. As many genera were not available in this country, approximately 10 months of the past year were spent in western Europe visiting museums and other institutions and searching for and restudying the European types of Foraminifera. New descriptions were written from the actual specimens and the types were refigured by Helen Tappan Loeblich in these institutions. Other specimens figured in the present paper, from the collections of the U. S. National Museum in Washington, D. C., were illustrated by Lawrence Isham.

In connection with the preparation of the present paper we wish to acknowledge the invaluable assistance given to us by various institutions and individuals. The British Museum (Natural History), in London, very graciously allowed us unrestricted access to their foraminiferal collections, and we were personally aided there by Dr. H. W. Parker, head keeper of zoology, Dr. Norman Tebble, and A. G. Davis. We not only examined types in the collections of Brady, Heron-Allen and Earland, Williamson, Sidebottom, Parker and Jones, and Carter, but also examined the original faunal slides and samples in many instances, and were allowed to designate lectotypes from the original cotypes of many of these workers.

In France, with the kind permission of M. Roger, we were allowed to borrow types from the Muséum National d'Histoire Naturelle, in Paris, and to select lectotypes for species of d'Orbigny and of Terquem. Other types were borrowed from the collections in the Sorbonne in Paris.

We are also grateful to the Bureau des Recherches Géologiques et Géophysiques, in Paris, for allowing us to use their laboratory during our stay in Paris, and to M. Pierre Marie, chief micropaleontologist there, who aided us in locating and borrowing various type specimens in Paris.

L'Institut Français du Petrole also allowed us to work in their laboratory at Rueil-Malmaison and to examine and illustrate types in their collection. We are especially grateful to Mme. Yvonne Gubler and M. Lys for their assistance.

In addition to these institutions and individuals that were of great assistance in the study of the Recent genera here included, we are also equally indebted to many of the other geologists, paleontologists, and zoologists of western Europe for their assistance in the study of fossil forms. We will more completely acknowledge their aid in forthcoming revisions of these fossil genera.

These generic studies cannot be made solely in museums, and it has often been necessary to obtain topotype material to understand better the genera. Therefore, in addition to our museum studies, we also collected large quantities of topotype foraminiferal material in western Europe, with the aid of the local specialists while in the field. We visited many university, museum, and petroleum company laboratories in order to observe the various methods of preparing samples, labeling slides, and storing collections, and received many valuable suggestions as to these techniques.

We are extremely grateful for the cooperation of the micropaleontologists throughout the world in our restudy of the genera. Many have cooperated by exchanges of material and literature, by showing us the localities in the field, and by demonstrating varied techniques in the laboratory.

DIFFICULTIES ENCOUNTERED IN FORAMINIFERAL SYSTEMATICS

We have been profoundly disturbed in our generic studies by certain factors which we have observed that seem to have added to confusion rather than to the clarification of taxonomic problems. Modern authors have sometimes been as lax with taxonomic matters as the worst of the early systematists. We are therefore giving here our observations on faults that future workers on Foraminifera would do well to avoid.

Lack of preparation of material.—It is obviously a time-consuming procedure to wash samples. Nevertheless, when material is found that is sufficiently interesting to warrant description, it is extremely important that the material be completely prepared and as clean as possible. The procedure used by us on all samples is first to wash by means of an extremely fine screen and spray or use the triple decanting method, sometimes with hydrogen peroxide or other aids as well, and then always to boil the samples for a length of time varying from a few hours to as long as a week if necessary.

It is also important to wash Recent samples thoroughly, although this has often been more or less neglected in the past. Merely because

the muds are not consolidated, it has been thought unnecessary to boil them. Strangely enough we have found that many Recent genera are very incompletely known, owing entirely to lack of sufficient preparation. Examples discussed later in this paper include one genus described as having a trematophore when actually the aperture was filled only by a shell fragment. Another genus was described as having an amorphous material between and around the chambers, which was in fact only the lime muds that had settled on the specimen and had not been removed by washing. In other forms, both Recent and fossil, the apertural characters or umbilical areas have been obscured by extraneous material which a little care in preparation could have removed. Another reason for the necessity of thoroughly washing samples is the fact that in Recent samples there is apparently sometimes a chemical action of the sea salts on the calcareous Foraminifera after a few years exposure to the air. We have seen specimen after specimen in museums that seem to have "exploded," and for no apparent reason other than this chemical reaction.

With the increased detail of foraminiferal studies it can be seen that many genera require additional techniques. In earlier years it was thought necessary to make thin sections only of the so-called "larger Foraminifera." Later workers have shown that extremely important features can be seen only by means of very careful dissection, and it has now become necessary to make dissections or thin sections of many genera of smaller Foraminifera in order to determine correctly their development. For example, one genus was described with a supposed early planispiral coil, but a thin section now shows the form to have a much more complex early chamber arrangement; others are found to have hitherto unsuspected internal tubes, chamberlets, or distinctive wall structures. Thus it becomes necessary to prepare material very thoroughly before describing new species and genera.

Too much dependence on literature.—It is of course imperative to have available as much literature as possible in order to do taxonomic work. It is equally important not to be too dependent on literature. In the final analysis, it is necessary to compare actual specimens. This is extremely important in describing new forms. Although it may seem certain that a specimen at hand is identical with that of Brady, Parker and Jones, or others, it is dangerous to assume this without recourse to the types. Thus various authors have cited so-called "classic species" as types for new genera, firmly believing their specimens to be identical with the original types, only to find later that the specimens were not even congeneric. It is always best to base genera

on species at hand, and if not a new species, it would be advisable to have or see authentic types of the species used.

Often misinterpretations of figures may cause difficulties—an internal tube may be shown in a figure but be thought to represent merely a highlight, or because the figures do not show certain important characters, such as apertures, septa, or other features, later workers may erroneously assume these to be like those of specimens at hand. For example, arenaceous genera have been described, and calcareous forms unknowingly selected as type species. Brady's *Challenger* monograph of Recent Foraminifera was one of the most inclusive foraminiferal works available, and many authors have selected species of Brady as types for new genera. Fortunately, his figures and descriptions are in general remarkably accurate and his types well labeled and preserved. This work covered only Recent species, however, and many fossil genera are not included in Brady's work. Other workers have used works of d'Orbigny, Terquem, Reuss, Quenstedt, and others as a basis for their taxonomic revisions, and with resultant confusion, as the original illustrations were often not accurate, nor the diagnoses thorough. In the last decade the Ellis and Messina Catalogue of Foraminifera has tended to supplant other works as a basis for taxonomic "revisions." Although an invaluable tool for research in supplying original descriptions and figures, this compilation can also be misused by modern students of Foraminifera who "discover" new genera by turning its pages. Too many of the "original figures" which it reproduces are not as reliable as those of Brady, and many errors arise when revisions are made on the sole basis of these illustrations and descriptions, without consideration of the reliability of their authors. As students of Foraminifera are to be found in almost every area of the globe, it would seem better to increase the frequency of exchanges of specimens, so that those wishing to make generic revisions can see at first hand the species or genera they are studying, and not depend solely on the literature.

Lack of responsibility for preservation of types.—It would seem that anyone describing new species or genera would have sufficient interest in their own work to desire its validation and preservation. Unfortunately, many writers seem to feel that their responsibility ends when their manuscript reaches an editor. Type specimens are not labeled, locality data are insufficiently given in publications and on the slides, the depository of the types is not always cited, and sometimes types are even kept in private collections. Naturally, it is convenient to have one's types at hand in case one wishes to consult them again at a future

date, but too often they are forgotten completely and eventually lost. Even such a pioneer systematist as d'Orbigny, having kept his types in a personal collection, was unable to prevent the loss of many. After his death the types that were located were sent to the Muséum National d'Histoire Naturelle in Paris, but only about one-third were thus preserved, the remainder having been lost or destroyed. Types can always be consulted again if deposited in a reliable institution.

Most museums have time after time received from authors types that were only partially labeled, perhaps in pencil, or even completely without labels. In some instances numerous specimens may be on a single slide with no indication as to which is the type or which have been figured. The curators in charge must then spend many days attempting to identify the types and label them properly, but we have seen instances in some institutions where many years after publication the "types" remain unlabeled and can be recognized only by their authors. In some instances genera have been based on species whose types, thus kept, cannot now even be identified.

Sometimes more than one specimen is present on a slide with no indication as to which is the type, or the author may have designated many cotypes rather than a holotype and paratypes. In this case a succeeding worker may select one of these specimens as lectotype, which takes the place of a holotype, thus delimiting exactly the species. We have done this in many instances—for example, in the d'Orbigny collection. The original d'Orbigny slides sometimes contained more than one species as they are now understood, and often more than one genus as well. Then the specimens selected as lectotype must determine the entire character of the genus, regardless of original descriptions or later understanding of the genus. When selecting lectotypes we have invariably attempted to locate the specimen figured by the author and that most clearly corresponding to his description. We have also in each instance noted on the slide that the specimen has been designated as lectotype for the aid of later workers.

It is far preferable, however, that the original authors definitely select the holotype for the new species, and furthermore that they so label their preparations that no doubt can remain. Not only should the specimen be labeled as to name and author and what sort of type, but also more exact locality data should be given so that future workers would be able to obtain topotype material. As many types have been lost through the years, it has been necessary to search for additional material from the original locality in order to determine the characters of the species. It is much easier to obtain authentic material from

well-documented localities than from one given simply as Cretaceous of Texas or fossil from Italy.

Furthermore, the original publication should state definitely which specimen is the holotype, or other primary type, give exact data as to locality and horizon, and also state in what institution the types are deposited and list the catalog numbers if such are available.

GENERIC DIAGNOSES

Genus BRACHYSIPHON Chapman, 1906

Plate 1, figure 1

Original description.—New Zealand Inst., Trans. Proc., vol. 38 (21st of n. s.), pt. 2, art. 17, p. 83, 1906.

Type species.—*Brachysiphon corbuliformis* Chapman, 1906. Original designation; monotypic.

Diagnosis.—Test free, elongate, cylindrical; wall agglutinated, incorporating numerous small Foraminifera and other shell fragments, as well as sand grains, on a "chitinous" base or internal lining; aperture an irregular opening at the slightly constricted end of the tube.

Types.—Original types from lat. 36°8′ S., long. 175°55′ E., off Great Barrier Islands, North Island, New Zealand, at 110 fathoms depth, and are probably in the Melbourne Museum. The figured specimen is a topotype in the Sidebottom Collection, B.M.N.H. No. ZF 3572, from off the Great Barrier Islands, New Zealand.

Discussion.—Cushman (1948, p. 78) stated that this genus was possibly synonymous with *Proteonina* Williamson, 1858. As has been shown elsewhere in this article, *Proteonina* Williamson is synonymous with *Reophax* and hence quite unlike *Brachysiphon.*

Brachysiphon differs from *Saccammina* M. Sars, 1869, in the elongate cylindrical form and from *Lagenammina* Rhumbler, 1911, in the parallel sides and in lacking a constricted neck. It superficially resembles a *Bathysiphon,* but is closed at one end and much shorter. Galloway (1933, p. 74) stated that it was as wide as long and with a proloculum at one end, but these statements are not borne out by an examination of the topotypes in the British Museum.

Genus PROTEONINA Williamson, 1858, emended

Plate 1, figures 2, 3

Original description.—On the Recent Foraminifera of Great Britain, Ray Soc. London, p. 1, 1858.

Type species.—Proteonina fusiformis Williamson, 1858. Subsequent designation by Rhumbler (1904, p. 244).

Diagnosis.—Test elongate, fusiform in outline, consisting of a subglobular proloculus and elongate, flask-shaped later chambers, few in number; sutures somewhat obscure or slightly constricted from the exterior, nearly horizontal; wall agglutinated, with coarse particles; aperture terminal, rounded, slightly produced.

Types.—Williamson's types are deposited in the B.M.N.H., lectotype (here designated) No. ZF 3605 (fig. 2) and paratype No. 96.8.13.1 (figs. 3a, b), both Recent, from Skye, in sand dredged by Mr. Barlee.

Discussion.—Williamson's figured specimen was a three-chambered form (a typical *Reophax*) with somewhat indistinct sutures due to the coarseness of the particles in the agglutinated wall. Williamson (1858, p. 1) stated in his generic diagnosis that *Proteonina* possessed "a slight disposition in its young state to become convoluted"; but he says also, "I have hitherto failed in tracing any internal septa in the *Proteonina.*"

Williamson described also *P. pseudospiralis* (1858, figs. 2, 3), but his types are apparently lost. From the illustrations it seems to be generically distinct from *P. fusiformis,* as it is compressed and has a narrow slitlike aperture and the outline of the test suggests an initial coil.

Proteonina thus is a multilocular, uniserial agglutinated form, and not a single-chambered form as has been commonly considered. The name *Proteonina* is therefore suppressed as a synonym of *Reophax* Montfort, 1808. The majority of other species that have been placed in *Proteonina* can be placed in *Saccammina* Sars, 1869, *Lagenammina* Rhumbler, 1911, or other genera, and there seems no necessity to create another generic name to replace *Proteonina.*

PLANCTOSTOMA Loeblich and Tappan, new genus

Plate 1, figures 6-12

Type species.—Textularia luculenta Brady, Rep. voyage *Challenger,* vol. 9 (Zoology), p. 364, pl. 43, figs. 5-8, 1884.

Derivation.—planktos Gr., wandering, roaming + *stoma* Gr., mouth. Gender, neuter.

Diagnosis.—Test free, elongate, chambers biserially arranged, but in rare specimens the last chambers may lose the biseriality and become central, very rarely the last few chambers being uniserial; wall agglutinated, simple in structure; aperture at the base of the last

chamber in the young stage, but moves rapidly up into the face and typically consists of a rounded opening in the terminal face, commonly somewhat off-center; occasional specimens may even have a multiple aperture of two or three rounded openings.

Types.—Brady (1884, p. 365) recorded *Textularia luculenta* from five localities, three in the North Atlantic (off Sombrero Island, 450 fathoms; off Culebra Island, 390 fathoms; and off Bermuda, 435 fathoms) and two in the South Atlantic, near the coast of South America and a little south of Pernambuco, 675 fathoms and 350 fathoms respectively. Lectotype (here designated), the specimen figured by Brady (1884, pl. 43, fig. 5), in B.M.N.H. Hypotype of figure 8 (U.S.N.M. No. P 2185) and unfigured hypotypes (U.S.N.M. No. 16946) from *Albatross* station D 2150, lat. 13°34′45″ N., long. 81°21′10″ W., bottom temperature 45.75° F., 382 fathoms; unfigured hypotypes (U.S.N.M. No. P 2186) from *Albatross* station D 2355, lat. 20°56′48″ N., long. 86°27′00″ W., 399 fathoms; unfigured hypotype (U.S.N.M. No. 17025) from *Albatross* station D 2614, lat. 34°09′00″ N., long. 76°02′00″ W., 168 fathoms; unfigured hypotype (U.S.N.M. No. 17026) from *Albatross* station D 2644, lat. 25°40′00″ N., long. 80°00′00″ W., bottom temperature 43.4° F., 193 fathoms; hypotypes of figures 11, 12 (U.S.N.M. No. P 2195a, b) and unfigured hypotypes (U.S.N.M. No. 17027) from *Albatross* station D 2659, lat. 28°32′00″ N., long. 78°32′00″ W., bottom temperature 45.2° F., 509 fathoms; unfigured hypotype (U.S.N.M. No. P 2187) from *Albatross* station D 2660, lat. 28°40′00″ N., long. 78°46′00″ W., bottom temperature 45.7° F., 504 fathoms; unfigured hypotypes (U.S.N.M. No. 17028) from *Albatross* station D 2668, lat. 30°58′30″ N., long. 79°38′30″ W., bottom temperature 46.3° F., 294 fathoms; unfigured hypotypes (U.S.N.M. No. 17029) from *Albatross* station D 2677, lat. 32°39′00″ N., long. 76°50′30″ W., bottom temperature 39.3° F., 478 fathoms; unfigured hypotypes (U.S.N.M. Cushman Coll. No. 35149) from Harvard-Havana Expedition *Atlantis* station 2980, lat. 22°48′ N., long. 78°48′ W., 225 fathoms; unfigured hypotypes (U.S.N.M. No. P 2189) from Johnson-Smithsonian Expedition station 25, lat. 18°32′15″ N., long. 66°22′10″ W., lat. 18°32′05″ N., long. 66°22′10″ W., 240 to 300 fathoms; unfigured hypotypes (U.S.N.M. No. P 2190) from Johnson-Smithsonian Expedition station 37, lat. 18°13′50″ N., long. 67°39′20″ W., lat. 18°11′56″ N., long. 67°42′50″ W., 160 to 200 fathoms; hypotype of figure 6 (U.S.N.M. No. P 2191) and unfigured hypotypes (U.S.N.M. No. P 2192) from Johnson-Smithsonian Expedition station 93, lat. 18°38′ 00″ N., long. 69°09′30″ W., lat. 18°37′45″ N., long. 65°05′00″

W., 350 to 400 fathoms; hypotypes of figures 7 and 9 (U.S.N.M. No. P 2193a,b) and unfigured hypotypes (U.S.N.M. No. P 2194) from *Challenger* station 23, off Sombrero Island, West Indies, 450 fathoms; and hypotype of figure 10 (U.S.N.M. No. P 2188) and unfigured hypotypes (U.S.N.M. No. P 2194) from *Challenger* station 24, Culebra Island, north of St. Thomas, West Indies, 390 fathoms.

Discussion.—In the early stages (fig. 6) *P. luculentum* is typically textularian in that the aperture is at the base of the final chamber, but in mature specimens (figs. 8, 9) the aperture migrates into the face of the terminal chamber, becoming terminal, and a rare individual or "freak" develops a bigenerine stage as shown in figure 7.

A count was made of the apertural characters of our specimens of this species. Of 283 specimens examined, 249 had a biserial test and a terminal aperture (88 percent); 25 had a biserial test and textularian aperture (8.8 percent), but these were largely juvenile forms; 5 had terminal uniserial chambers and terminal aperture (1.8 percent); and 4 specimens showed a multiple terminal aperture (1.4 percent).

Brady (1884, p. 365) concluded that this migratory feature of the aperture was of minor importance and included his species in *Textularia.* He stated that this distinctive apertural character led to the proposal of a distinct genus *Proroporus;* however, the latter is a calcareous form and species referred to it probably belong to *Bolivina* and *Loxostomum.* Goës (1896, p. 24) has called attention to the fact that *Textularia saulcyana* d'Orbigny, 1839, may be a dwarfed form of this species and if so should take preference over this specific name. However, until types of d'Orbigny's species are examined, the writers prefer to keep the two forms separate inasmuch as d'Orbigny's drawings seem somewhat generalized.

Planctostoma, new genus, differs from *Textularia* Defrance in having an aperture in the later stages terminal on the last chamber rather than at the base of the last chamber. It is differentiated from *Bigenerina* in lacking the uniserial stage of that genus. The rare specimen here illustrated (fig. 7) with the bigenerine stage is regarded as a "freak." From *Siphotextularia* this genus is differentiated in lacking the quadrangular outline of that genus and also in having a rounded aperture instead of a slitlike aperture on the terminal face with a projecting rim. *Planctostoma* as presently known is represented by the species *luculentum* and *saulcyana,* both from the Caribbean region. Specimens figured by Lalicker and McCulloch (1940, pl. 16, fig. 22a-d) as *Textularia saulcyana* d'Orbigny from the Pacific are not this species and should not be confused with *T. saulcyana.*

Genus TEXTULARIOIDES Cushman, 1911, emended

Plate 1, figures 4, 5

Original description.—U. S. Nat. Mus. Bull. 71, p. 26, 1911.

Type species.—*Textularioides inflata* Cushman, 1911. Original designation.

Diagnosis.—Test attached at least in the early stages; chambers in a biserial textularian arrangement, somewhat flattened against the attachment, later portion often growing free of the attachment; wall agglutinated, with coarse grains embedded in a fine ground mass which is pierced by numerous tiny pores connecting the interior to the exterior; aperture a low arch or slit at the base of the final chamber.

Types and discussion.—Originally the genus was known from the holotype of the type species (U.S.N.M. No. 8337) from *Albatross* station D 4900, in 139 fathoms, off the coast of Japan. A prolonged search through the original sample by the writers has supplied a number of topotypes (U.S.N.M. No. 560423) which bring out additional characters not originally described. The specimen here illustrated, figure 4 (U.S.N.M. No. P 2196a), shows the final two pairs of chambers growing free of the attachment, and the typical low, slitlike aperture. Another specimen (fig. 5), which is broken free of the attachment, shows on the attached side the radial wall structure pierced by many pores. This type of structure has been noted in other agglutinated forms (see Wood, 1949, p. 234) such as *Tritaxia capreolus* Brady, *Textularia porrecta* Brady, and *Textularia rugosa* Reuss, and is undoubtedly more common in the agglutinated forms than has been suspected in the past.

Genus JULLIENELLA Schlumberger, 1890

Plate 1, figures 13, 14

Original description.—Soc. Zool. France, Mém., vol. 3 (1890), pt. 1, p. 213, 1889.

Type species.—*Jullienella foetida* Schlumberger, 1890. Monotypic.

Diagnosis.—Test large, flabelliform, occasionally with large fan-shaped portions extending in two directions from a central attachment, margin produced into numerous tubules, interior irregularly subdivided by a series of intermittent radiating ridges, which are not reflected on the exterior (fig. 14b); interior surface has many large pores, which apparently connect with much more restricted openings at the surface, wall firm, finely arenaceous, with much ferruginous cement, insoluble in hydrochloric acid, surface transversely wrinkled;

apertures numerous, a small rounded opening at the end of each of the tubular extensions along the periphery; color reddish brown.

Types.—Topotype from paleontological collection in the Sorbonne, Paris, France, from the collection of Dr. Jullien, 1887, Warabo or Watabo, bank of Poor River, coast of Liberia, at 7 fathoms.

Discussion.—Galloway (1933, p. 200) referred to this genus as being chitinous, and Cushman (1948, p. 171) stated that it had a flexible test. Neither statement seems to agree with the specimens. Schlumberger stated that the wall consisted of siliceous sand grains cemented by chitinous material, but he also stated that it had a very resistant agglutinated test. The specimens we examined in Paris have a very rigid test, agglutinated and with ferruginous cement with no indication of "chitin."

Genus MILIAMMINA Heron-Allen and Earland, 1930, emended

Plate 1, figures 15, 16

Original description.—Journ. Roy. Micr. Soc. London, ser. 3, vol. 50, p. 41, 1930.

Type species.—*Miliolina oblonga* (Montagu) var. *arenacea* Chapman, 1916. Subsequent designation by Cockerell (1930, p. 975).

Diagnosis.—Test free, chambers arranged in a quinqueloculine plan; wall siliceous, insoluble in hydrochloric acid, composed of minute mineral grains in an excess of siliceous cement, smoothly finished or polished in appearance, more rarely roughened; aperture terminal, with a tooth formed by the infolding of the wall.

Types.—Chapman's type was from the Recent at 462 fathoms, lat. 76°46′ S., long. 163°26′ E., Ross Sea, Antarctic. We were unable to find this type in the collections of the British Museum. Our figures are of the specimens of Heron-Allen and Earland, in the B.M.N.H.

These specimens were included by Heron-Allen and Earland in Chapman's species at the time they described the genus *Miliammina.* However, in later publications they considered the South Georgia form to be distinct from *Miliammina arenacea* (Chapman), differing in a more ovate and rounded outline rather than having the parallel sides of Chapman's species. Originally described as the variety *arenacea* of *Miliolina oblonga* (Montagu) by Chapman, it was incorrectly referred to *Miliammina oblonga* (Chapman) by Heron-Allen and Earland (1930, p. 41) and then to *Miliammina arenacea* (Chapman) in later publications of Earland (1933, p. 92, and 1934, p. 110). Also Earland, considering their South Georgia form a separate species, renamed it *Miliammina oblonga* Heron-Allen and Earland (1933, p. 92), citing it again thus in 1934 (p. 111).

This specific name could not be thus used, however, as it had been previously used by Montagu for the species *Miliolina oblonga,* and as this species had been earlier placed, even though erroneously, in the genus *Miliammina,* the name was not available for another species of the same genus. Thus the South Georgia form lacks a specific name, and we here propose the new name *Miliammina earlandi,* for *M. oblonga* Heron-Allen and Earland (1933, p. 92).

The large specimen here figured (B.M.N.H. No. ZF 3406) is here designated lectotype and is from 200 meters, off South Georgia, R.R.S. *William Scoresby* station 43, lat. 54°54′ S., long. 36°50′ W. The sectioned specimen (ZF 3407) is from R.R.S. *William Scoresby* station 50, from 230 meters, lat. 54°30′30″ S., long. 38°40′30″ W., off South Georgia.

Discussion.—Cushman (1948, p. 174) stated that *Miliammina* is planispiral in the early stages. This statement is apparently based on a misinterpretation of the figured sections of Heron-Allen and Earland (*in* Earland 1933, pl. 5, figs. 7, 8), which were cut in the long axis of the test and not transversely. The transverse section here figured (fig. 16) shows that this genus is definitely quinqueloculine in plan.

Originally Heron-Allen and Earland included in *Miliammina* species with either a quinqueloculine or triloculine chamber arrangement. We are here emending *Miliammina* to include only those species which, like the type species, are quinqueloculine. The triloculine species are here separated in a new genus, *Trilocularena.*

TRILOCULARENA Loeblich and Tappan, new genus

Plate 2, figure 1

Type species.—Miliammina circularis Heron-Allen and Earland, 1930, Journ. Roy. Micr. Soc. London, ser. 3, vol. 50, p. 44, figs. 18-21.

Derivation.—tri L., three+*loculus* L., cell, dim. of *locus*+*harena* L.=*arena,* sand. Gender, feminine.

Diagnosis.—Test free, chambers arranged in a triloculine plan; wall arenaceous, composed of minute mineral grains in an excess of siliceous cement, surface smoothly finished; aperture terminal, with a broad, shallow tooth formed by an extension of the lip.

Types.—Heron-Allen and Earland selected no holotype for their species. The specimen here figured, B.M.N.H. No. ZF 3563, is here designated as lectotype, and the remaining specimens (ZF 3567) are paratypes. These are from *Discovery* station D 182, Schollaert Channel, Palmer Archipelago, Antarctica, lat. 64°21′ S., long. 62°58′ W., at a depth of 278 to 500 meters. Heron-Allen and Earland also

record the species from *Discovery* station 363 at 2.5 miles S. 80° E. of the southeast point of Zavodovski Island, South Sandwich Islands, at 329 to 278 meters depth.

Discussion.—Heron-Allen and Earland included this triloculine species with their quinqueloculine arenaceous forms in the genus *Miliammina.* However, in view of the distinctive chamber arrangements, long considered a valid reason for separation of the calcareous Miliolidae, we here consider the triloculine species to belong to a separate genus. *Miliammina oblonga* Heron-Allen and Earland forma *sabulosa* Rhumbler, 1936, is apparently also a typical *Trilocularena* and should be referred to *Trilocularena sabulosa* (Rhumbler).

Genus **HAUERINA** d'Orbigny, 1839

Plate 2, figure 2

Original description.—*In* Ramon de la Sagra, Histoire physique, politique et naturelle de l'Île de Cuba, p. 38, Paris, 1839.

Type species.—*Hauerina compressa* d'Orbigny, 1846. First species published in the genus.

Diagnosis.—Test free, compressed, equilateral, subcircular in outline, early stages quinqueloculine, later planispiral with three or more chambers to a whorl; wall calcareous, porcellaneous, imperforate; aperture a series of pores in a sievelike plate, the trematophore.

Types.—The holotype (here figured) is deposited in the M.N.H.N., Paris, and is from the Miocene of the Vienna Basin.

Discussion.—D'Orbigny's original description of the type species stated that it had only an oval aperture, surrounded by numerous tubercles. Later references have stated that the species had a cribrate aperture, but most later references to this species have been misidentifications. The species is apparently restricted to the Miocene of the Vienna Basin. The holotype is here described and figured for comparison with the new genus *Involvohauerina.*

The figure shows the keeled form of this species, and a ridge shown to one side of the keel in the figure is the remains of a later chamber that was broken away.

INVOLVOHAUERINA Loeblich and Tappan, new genus

Type species.—*Involvohauerina globularis* Loeblich and Tappan, new species.

Derivation.—*involvo* L., to roll up, wrap up + *Hauerina,* patronymic name for de Hauer. Gender, feminine.

Diagnosis.—Test free, early portion quinqueloculine, later tending to become planispiral and involute with three chambers per whorl and only those chambers of the last whorl visible; wall calcareous, porcellaneous, imperforate; aperture consisting of numerous irregularly shaped pores extending up from the periphery over a broad area of the apertural face.

Discussion.—This genus is closest to *Hauerina* d'Orbigny but differs in being almost globular rather than compressed, and in being involutely coiled rather than showing many of the early whorls as does *Hauerina.*

INVOLVOHAUERINA GLOBULARIS Loeblich and Tappan, new species

Plate 2, figures 3-8

Diagnosis.—Test free, subglobular in form, early portion quinqueloculine, later becoming planispiral and involute, although some specimens are somewhat off center, only the three chambers of the last whorl visible externally, except in a single specimen, which is sufficiently off center to allow four chambers to be visible, periphery very broadly rounded; sutures distinct, slightly depressed; wall calcareous, porcellaneous, imperforate, surface smooth, but very minutely pitted; aperture consisting of numerous irregularly shaped pores extending up from the periphery over a broad area of the apertural face.

Greatest diameter of holotype 1.93 mm., least diameter 1.41 mm., greatest thickness 1.85 mm. Other specimens vary from 1.66 to 2.68 mm. in diameter.

Types and occurrence.—Holotype, figure 3 (U.S.N.M. No. P 2202), and paratypes of figures 4-7 (U.S.N.M. No. P 2203a-d) and unfigured paratype B.M.N.H., London, from *Albatross* station D 2035, lat. 39°26′16″ N., long. 70°02′37″ W., depth 1,362 fathoms, *Globigerina* ooze; paratype of figure 8 (U.S.N.M. No. P 2204) from *Albatross* station D 2859, lat. 55°20′00″ N., long. 136°20′00″ W., bottom temperature 34.9° F., depth 1,569 fathoms, gray ooze.

Discussion.—This species is closest to *Hauerina involuta* Cushman in general chamber arrangement, but differs in being subglobular in form, and not compressed with an acute periphery. *H. involuta* also has an ornamented surface, showing distinct transverse ridges, crossed by fine striae.

Genus TRISEGMENTINA Wiesner, 1920, emended

Original description.—Zool. Anzeig., vol. 51, p. 18, 1920.

Type species.—*Trisegmentina compressa* Wiesner, 1931. Subsequent designation by Wiesner, 1931, p. 70 (see discussion below).

Type.—The holotype of *Trisegmentina compressa* Wiesner (Sidebottom's *Hauerina compressa* d'Orbigny) is in the British Museum (Natural History).

Discussion.—Wiesner first described this genus in 1920 and not in 1931 as stated by Cushman (1948, p. 198), or in 1923 as stated by Ellis and Messina (Catalogue of Foraminifera). Originally described without naming species, *Hauerina compressa* Sidebottom was later cited by Wiesner (1931, p. 70) as type species. This was the species described by Sidebottom (1904, p. 19) as *Hauerina compressa* d'Orbigny. Cushman (1933, p. 165) renamed Sidebottom's form *Trisegmentina sidebottomi,* but this name must be considered merely a junior synonym of *Trisegmentina compressa* Wiesner, 1931. This case is covered in detail in the recent Copenhagen Decisions on Zoological Nomenclature by Hemming (1953, p. 68). Quoting Hemming (p. 69), "A similar unsatisfactory situation arises where an author of a generic name, without designating a type species for the nominal genus so established, places in it a species under a name which he clearly indicates that he is using in a different sense from that of its original author, and the species so indicated is the first of the included species to be selected as the type species under Rule (g) in Article 30." In such a case as this "the type species of the new genus is to be treated as having been given a new binomen composed of the cited generic name and of a specific name consisting of the same word as that borne by the species under which the type species was erroneously cited by the author of the new generic name." Thus the type species must be cited as *Trisegmentina compressa* Wiesner, 1931, and Cushman's name *T. sidebottomi* is a junior synonym.

The figures given by Sidebottom (1904, pl. 5, fig. 8) show an apertural plate with pores (trematophore). An examination of the type specimen (B.M.N.H.) showed this apparent pore plate to be a fragment of extraneous calcareous material lodged in the aperture, but not an actual part of the specimen. The form is thus merely a *Planispirina,* and as *Planispirina* was described by Seguenza in 1880, the name *Trisegmentina* Wiesner is here suppressed as a junior synonym.

Genus **POLYSEGMENTINA** Cushman, 1946, emended

Plate 3, figures 1-3

Original description.—Contr. Cushman Lab. Foram. Res., vol. 22, pt. 1, p. 1, 1946.

Type species.—*Hauerina circinata* Brady, 1881. Original designation.

Diagnosis.—Test free, discoidal, early portion milioline in plan, later planispiral and slightly involute, with three to six chambers in the final whorl, the later chambers being relatively shorter, so that the number per whorl gradually increases; wall thickened, calcareous, imperforate; aperture consists of numerous irregular pores in a trematophore, the marginal row of pores being left exposed in the earlier chambers and remaining as sutural pores connecting with the interior.

Types.—The specimen of figure 1 (B.M.N.H. No. ZF 3629) is here designated as lectotype. It is from *Challenger* station 187A, at a depth of 8 fathoms, off Booby Island, and is the specimen figured originally by Brady. The sectioned specimens (figs. 2, 3) are in the collection of the U.S.N.M. (No. P 2197a,b) and are from Torres Strait. Brady's other syntypes are here considered paratypes (B.M.N.H. No. ZF 1565) and are from the same locality as the lectotype.

Discussion.—In the description of the genus *Polysegmentina,* Cushman (1946, p. 1) stated that "A study of the structure and development of this form [*Hauerina circinata* Brady] shows that it is not a *Hauerina,* as the early stages are not quinqueloculine but apparently planispiral and related to *Cornuspira.*" He described *Polysegmentina* as having "the early stages similar to *Cornuspira* with proloculum and planispirally coiled second chamber several coils in length." This description was apparently based on a misinterpretation of a figure given by Rhumbler (1906, pl. 3, fig. 40), an exterior view (copied by Cushman, 1946, pl. 1, fig. 4) which seemed to show a planispiral early development. Examination of Brady's types in the British Museum shows that this apparent planispiral coiling is only the faint surface reflection of the spiral suture, largely obliterated by the thin shell layers of the later nearly involute coils, and that only the chambers of the last one and one-half or two whorls can be determined surficially. We have had thin sections prepared and these show that the early portion is milioline and definitely not planispiral, and that there is no undivided second chamber of several coils in length.

Brady had even stated (1884, p. 190) that he placed in *Hauerina* only "the planospiral porcellaneous Foraminifera which are Milioline only in the very early stages of growth," and although he had not sectioned the species as proof, his statements, as so often found, were closer to being accurate than those of later workers. The bases on which Cushman separated this species from *Hauerina* are completely invalid and do not warrant its separation as a separate genus.

However, the genus *Polysegmentina* may be separated on a different basis, and we are here emending the diagnosis, separating this genus from *Hauerina* because of the peculiar retral processes along the

sutures which reflect the lateral pores of the apertures of earlier chambers. These pores continue to connect with the interior.

Genus TUBINELLA Rhumbler, 1906, emended

Plate 3, figures 11, 12

Original description.—Zool. Jahrb., Abt. Syst., vol. 24, p. 25, 1906.

Type species.—*Articulina funalis* var. *inornata* Brady, 1884. Subsequent designation by Cushman (1928, p. 151).

Diagnosis.—Test free, with a vestigial early milioline stage consisting of a bulbous proloculus and closely appressed second chamber, reversing the direction of growth; later chambers cylindrical and uniserially arranged; septa vestigial, consisting of slight transverse thickenings of the wall, visible in transmitted light; wall calcareous, imperforate; aperture at the open end of the tube.

Types.—Brady did not designate a holotype, having numerous specimens which are now labeled as syntypes. We are here designating as lectotype the larger specimen figured here (fig. 12), B.M.N.H. No. ZF 3656, from *Challenger* station 149 D at 20 to 60 fathoms, Balfour Bay, Kerguelen Island. Smaller paratype, here figured (fig. 11), also in the B.M.N.H.

Discussion.—The early portion has never been completely figured. Cushman (1948, p. 182) remarked "Test with an ovoid early portion." Galloway (1933, p. 131) referred to it as "initial chamber bulbous," basing these descriptions upon Brady's figures which do not show the subdivision of the early portion. However, in Brady's description of *Articulina funalis,* of which he considered *inornata* a variety, mention was made of this, as he stated "Milioline segments few and small, forming collectively a little inflated or bulbous projection at the narrower end of the shell."

At the time of original description of the genus *Tubinella,* Rhumbler included in it *Articulina funalis* Brady and *A. inornata* Brady, and a new species *Tubinella perforata* Rhumbler. He illustrated the species *T. perforata,* which is very close to his original definition of the genus, completely lacking any divisions in the early portion. It is probable that his definition of the genus was based on his own species, but unfortunately he failed to state this and no type was designated. In 1911 he described another species, *T. suspecta,* which also lacked any division of the early portion.

In 1928 Cushman selected Brady's species *Articulina funalis* var. *inornata* as the type species of *Tubinella.* In 1931 Wiesner (p. 67) described another genus, *Tubinellina,* for Brady's species *Articulina*

funalis, and stated that he would limit *Tubinella* to forms such as *T. perforata* Rhumbler. But this was impossible to do, as the type of *Tubinella* had previously been fixed. Thus Wiesner's genus *Tubinellina* immediately became a synonym.

The type species *Tubinella inornata* (Brady) is thus very close to *Articulina,* having in fact a milioline early stage, although in this species much reduced. The genus *Tubinella* is probably derived from *Articulina* by a reduction of the septa to mere wall thickenings.

Genus TRITAXIS Schubert, 1920, emended

Plate 3, figures 5, 6

Original description.—Paläont. Zeitschr., vol. 3 (1921), heft 2, p. 180, 1920.

Type species.—*Rotalina fusca* Williamson, 1858. Subsequent designation by Cushman, 1928, p. 171.

Diagnosis.—Test circular in outline, with a low trochoid spire, free in the early stage, later becoming attached by the ventral surface with an irregular spreading mass surrounding the regularly coiled early portion; chambers about 10 in number, at first nearly globular with 4 per whorl, then increasing in breadth much faster than in height so that chambers of the later whorls are low and crescentic when viewed from the dorsal side, and only 3 per whorl, last chamber occupying over one-half the ventral side but only a narrow crescent dorsally; sutures distinct, slightly depressed, strongly curved dorsally, nearly straight ventrally; wall agglutinated, comparatively coarse grained, surface roughened in appearance; aperture ventral, on free specimens an ovate opening at the base of the last formed chamber near the umbilicus, and surrounded by a distinct lip, not always visible in the attached later stages, but there may be tubularlike openings at the outer margins of the attached portion.

Types.—The types of Williamson's species are missing from the British Museum collections. The original localities given include Recent at Weymouth, Sandwich, Swansea, and dredged sands of Skye and Exmouth, British Isles. Figured hypotypes (U.S.N.M. No. P 2198a,b) from F. C. *Helga* Haul SR 331, lat. 51°12′ N., long. 11°55′ W., 610 to 680 fathoms, off southwestern Ireland.

Discussion.—Cushman designated *Rotalina fusca* Williamson as the type species for this genus in 1928, and at the same time placed *Tritaxis* in the synonymy of *Trochammina* Parker and Jones, 1860. Williamson did not figure the aperture of *R. fusca,* or describe the attached character, as his original specimens were free. Nevertheless,

this British form can be easily recognized by the low conical test with three chambers in the last whorl. Cushman defined *Trochamminella* in 1943, but as *T. siphonifera* is congeneric with *Rotalina fusca,* the name *Trochamminella* is a junior synonym of *Tritaxis* Schubert, 1920, and must therefore be suppressed.

Genus **TROCHAMMINELLA** Cushman, 1943

Plate 3, figure 7

Original description.—Contr. Cushman Lab. Foram. Res., vol. 19, pt. 4, p. 95, 1943.

Type species.—*Trochamminella siphonifera* Cushman, 1943. Original designation.

Diagnosis.—See under *Tritaxis* Schubert, 1920.

Types.—Holotype (U.S.N.M. Cushman Coll. No. 39619) from the Johnson-Smithsonian Expedition station 25, lat. 18°32′15″ N., long. 66°22′10″ W., at 240 to 300 fathoms, off Puerto Rico.

Discussion.—Cushman described *Trochamminella* as a specialized development from *Trochammina,* differing in the apertural characters. He figured both an unattached form with the ovate rimmed aperture, and an attached specimen surrounded by an irregular rim of material which extended at one side with an almost tubular protrusion, ending in a rounded opening. As can be seen from the figures, however, this form is identical with the genus *Tritaxis* Schubert, 1920 (type *Rotalina fusca* Williamson) ; hence *Trochamminella* Cushman, 1943, must be suppressed as a junior synonym.

Genus **ROTALIAMMINA** Cushman, 1924, emended

Plate 3, figure 4

Original description.—Carnegie Inst. Washington, Publ. 342 (Dept. Marine Biol. Papers, vol. 21), p. 11, pl. 1, figs. 4, 5, 1924.

Type species.—*Rotaliammina mayori* Cushman, 1924. Original designation.

Diagnosis.—Test attached, trochoid, all chambers visible dorsally, only those of the final whorl seen from the attached ventral side, ventrally umbilicate; wall very thin, agglutinated, with fine sand held in a small amount of cement; aperture indistinct, probably ventral.

Types.—Holotype (U.S.N.M. Cushman Coll. No. 511) from station 9, 50 fathoms, south of Breaker Point, between mouth of Pago Pago Harbor and Taema Bank, Tutuila, Samoa. Collected by A. G. Mayor.

Discussion.—The type species was originally described as having

"wall thick, of fragments of sponge spicules and fine amorphous material, the whole more or less flexible; sutures not apparent on the dorsal side, the outer portions of the chambers appearing as dark-brownish areas in the general mass of grayish-white amorphous material."

When we examined the "types," the dorsal surface showed a large amount of white "amorphous material," but which loosened when touched with a damp brush. The original figures of the holotype showed only the very highest points visible on the dorsal side, and all sutures and lower portions of the chambers were obscured. The so-called "amorphous material" was in fact only lime mud which had not been cleaned from the specimens. A gentle cleaning with a fine sable brush showed the characters to be much more like an attached *Trochammina*. We have figured the same specimen (the holotype, in fact) as is shown in the original description and in various editions of Cushman's text, but there is considerable difference in the appearance of the dorsal views.

Cushman's original description mentioned only the holotype. There is a single slide in the Cushman Collection which is marked holotype, but on which there are two specimens. As only one can be a holotype, we are assuming it to be that originally figured, and here reillustrated, and the other is considered to be a paratype.

Genus **BDELLOIDINA** Carter, 1877

Plate 3, figures 9, 10

Original description.—Ann. Mag. Nat. Hist., ser. 4, vol. 19, p. 201, (1877).

Type species.—*Bdelloidina aggregata* Carter, 1877. Original designation.

Diagnosis.—Test attached, with numerous broad and low chambers in a uniserial series or spreading and occasionally branching; wall agglutinated, rough externally, smooth inside with interior secondary septa vertically crossing the chambers from base to top, numerous internal pores pitting the interior and a row of communicating pores through the septal faces; aperture a single or double row of pores against the attachment on the terminal face of the last formed chamber.

Types.—Carter's specimens have not been found but were from excavations on the surface of a mass of *Siderastraea,* exact locality not given. Brady also recorded the species from *Challenger* station 218 A, Nares Harbor, Admiralty Islands, at 16 to 25 fathoms, and figured and described the internal secondary septa which had not been noted

by Carter. On this basis Elias (1950, p. 301) described as the variety *bradii* the specimens of Brady which showed the secondary septa. It seems very probable that the forms of Brady and Carter were identical, but Carter's figures were too diagrammatic to be diagnostic. The specimens here figured (fig. 9, U.S.N.M. No. P 2199) are from the Indian Ocean, exact locality unknown, and (fig. 10, U.S.N.M. No. P 2200) from the surface of a mussid coral on the seaward reef in about 3 feet of water, Namu Island, Bikini Atoll. Collected by F. M. Bayer.

Discussion.—Elias (1950, p. 301) discussed this genus from the literature and the problem as to whether it is labyrinthic (as stated by Carter, Brady, Chapman, and Galloway) or the interior simple as stated by Cushman.

The family position of this genus is also questionable. Cushman placed it in the Placopsilinidae, subfamily Placopsilininae, although this subfamily is not labyrinthic in the interior. Galloway placed it in the family Lituolidae, subfamily Neusininae, which is labyrinthic. Elias places *Bdelloidina* in his family Ptychocladiidae, although the type of this family is a calcareous genus, similar only in the attached character. It seems better kept in the Placopsilinidae, but in the subfamily Coscinophragminae with other labyrinthic forms.

Genus RIMULINA d'Orbigny, 1826, emended

Plate 3, figure 8

Original description.—Ann. Sci. Nat. Paris, sér. 1, vol. 7, p. 257, 1826.

Type species.—*Rimulina glabra* d'Orbigny, 1826. Monotypic.

Diagnosis.—Test free, elongate-ovate in outline, consisting of a single chamber in the holotype (and only specimen known); wall calcareous, smooth, finely perforate; aperture an elongate slit extending from the apex, about halfway down the side of the test, surrounded by a slight lip.

Types.—Holotype (here figured) from the Recent in the Adriatic, deposited in the M.N.H.N., Paris.

Discussion.—This species has been figured and described as possessing more than one chamber, and with very oblique sutures. These are not at all evident in the holotype, and a search failed to yield additional specimens to check this. Apparently no additional specimens have ever been seen. The writers examined the holotype in Paris, and both the color and appearance suggest that this specimen might well be a reworked fossil and not actually a Recent species.

Genus WEBBINA d'Orbigny, 1839

Plate 4, figure 6

Original description.—In Ramon de la Sagra, Histoire physique, politique et naturelle de l'Île de Cuba, p. 26, Paris, 1839.

Type species.—Webbina rugosa d'Orbigny, 1839. Subsequent designation by d'Orbigny *in* Barker-Webb and Berthelot (1839, p. 126). First species published under the genus.

Diagnosis.—Test attached by entire lower surface, chambers few in number, inflated, surface marked by faint transverse "growth lines," margins of chambers bordered by a fimbriate "keel"; wall thin, calcareous, appearing milky white and imperforate, surface smooth except for transverse wrinkles; aperture terminal, surrounded by a phialine lip.

Type.—Holotype in M.N.H.N., Paris. From the Recent, l'Île de Ténériffe, Îles Canaries. As far as known it is represented by a single specimen.

Discussion.—According to Galloway (1933, p. 296) this form is "coarsely perforate, with much secondary material making the surface rough." Cushman (1948, p. 339) states that the test is perforate. The original figures given by d'Orbigny for this species are very misleading. The holotype does not appear either coarsely perforate or with a roughened surface except for the fimbriate-appearing keel.

Genus MONALYSIDIUM Chapman, 1900

Plate 4, figure 5

Original description.—Linn. Soc. Journ. Zool. London, vol. 28, No. 179, p. 3, 1900.

Type species.—Peneroplis (*Monalysidium*) *sollasi* Chapman, 1900. Original designation.

Diagnosis.—Test free, consisting of numerous subglobular chambers, early ones arranged in an evolute planispiral coil, later portion uncoiled and rectilinear, with chambers subglobular; wall calcareous, distinctly perforate in appearance; aperture terminal, somewhat produced on a neck with phialine, fimbriate lip.

Type.—Holotype (B.M.N.H. No. ZF 3577) from beach at Avalau Island, Funafuti Atoll.

Discussion.—Monalysidium was originally described as a subgenus of *Peneroplis* Montfort, 1808. It seems similar to *Spirolina,* and not congeneric with the straight, uncoiled forms such as *M. politum* Chapman. Chapman stated that the test wall was imperforate and

tuberculate "with vertical rows of puncta, not perforations." They appear very similar to perforations, but unfortunately there is only the holotype in the British Museum, and it could not be sectioned to determine the wall structure.

Genus SCHUBERTIA Silvestri, 1912

Plate 4, figure 3

Original description.—Riv. Italiana Paleont., vol. 18, fasc. 2, 3, p. 68, 1912 (new name for *Millettia* Schubert, 1911, Abh. K. K. Geol. Reichsanst. Wien, Österreich, vol. 20, heft 4, p. 89 [not *Millettia* Duncan, 1889, and not Wright, 1899]).

Type species.—*Sagrina tessellata* Brady, 1884. Subsequent designation by Schubert (1911, review, p. 320).

Diagnosis.—Test free, elongate, narrow, arcuate, very early portion biserial, later portion consisting of a few elongate subcylindrical chambers, rapidly increasing in height and subdivided into chamberlets by vertical and horizontal partitions in a honeycomb pattern, the chamberlets arranged in regular transverse rows; wall calcareous, surface marked into hexagonal patterns by the junction of the chamberlet walls with the outer wall; aperture terminal, rounded with a slight lip.

Types.—Lectotype here designated as the specimen figured by Brady (1884, pl. 76, fig. 17) deposited in the B.M.N.H., No. ZF 2359, from *Challenger* station No. 219A, at a depth of 17 fathoms, Admiralty Islands.

Discussion.—Cushman stated (1929a, p. 338) that Brady's species showed no early biserial stage and that all chambers were subdivided. Examination of the type specimen shows 2 pairs of biserial chambers and an undivided uniserial chamber before the subdivision into chamberlets.

However, both Cushman (1948, p. 270) and Galloway (1933, p. 376) correctly describe the genus as having an early biserial stage followed by uniserial chambers, at first undivided and later with chamberlets.

Genus ORTHOPLECTA Brady, 1884

Plate 4, figures 1, 2

Original description.—Rep. voyage *Challenger,* vol. 9 (Zoology), pt. 22, pp. 355, 428, 1884.

Type species.—*Cassidulina* (*Orthoplecta*) *clavata* Brady, 1884. Monotypic.

Diagnosis.—Test free, elongate, narrow, slightly arcuate, of nearly equal diameter throughout, no regular chamber arrangement, but with a spiraling internal column, which gives an extremely irregular septation as it spirals and occasionally touches the exterior wall; wall calcareous, finely perforate with radial structure, aperture subterminal, ovate, just above a sutural junction.

Types.—Holotype (B.M.N.H. No. ZF 2064) from *Challenger* station 219A, at 17 fathoms, Admiralty Islands. Dissected hypotype here figured (B.M.N.H. No. ZF 3630) from F. W. Millett Collection, *Challenger* station 185, off Raine Island, Torres Strait, at 155 fathoms.

Discussion.—*Orthoplecta* was originally defined as a subgenus of *Cassidulina* d'Orbigny, 1826. However, there is no cassiduline early portion, and the later part is neither biserial nor irregularly biserial. Interestingly, Wood (1949, p. 244) noted that *Orthoplecta clavata* had a perforate radial structure, unlike the majority of the Cassidulinidae which have a perforate-granular structure. This difference in wall structure supports the separation of *Orthoplecta* from the Cassidulinidae and suggests its placement perhaps with the Ceratobuliminidae.

Genus CIBICIDOIDES Thalmann, 1939

Plate 4, figure 4

Original description.—Originally described by Brotzen (1936, pp. 186, 194), but as Brotzen did not designate a type species the genus was invalid until Thalmann designated the type in 1939, p. 448.

Type species.—*Truncatulina mundula* Brady, Parker, and Jones, 1888. Subsequent designation by Thalmann (1939, p. 448).

Diagnosis.—Test free, trochoid, biconvex and biumbonate, all chambers visible dorsally, only those of the final whorl visible ventrally; wall calcareous, hyaline, with a series of coarse perforations on the dorsal side, appearing only near the previous spiral suture in the early portion of the test, but covering a large portion of the dorsal side of the later chambers; aperture at the base of the apertural face of the final chamber, against the peripheral margin of the preceding whorl, consisting of a low arch with a slightly projecting lip.

Types.—Lectotype, here designated (B.M.N.H. No. ZF 3585), and paratypes (B.M.N.H. No. ZF 3584), all from *Plumper* station 4, at 260 fathoms, lat. 22°54′ S., long. 40° 37′ W., over Abrohlos Bank, off the coast of Brazil, South America.

Discussion.—*Cibicidoides* was originally described as a subgenus of *Cibicides* by Brotzen (1936, pp. 186, 194), but as he did not at that time designate a type species, the genus was invalid. He cited two

species, *Cibicides eriksdalensis* Brotzen and *C. mundula* (Brady, Parker, and Jones), but according to the International Rules of Zoological Nomenclature, Art. 25, c (3), a definite statement must be made as to the type species selected in order for a genus to be validated. Therefore, *Cibicidoides* became a valid genus when Thalmann designated as type species in 1939 *Truncatulina mundula* Brady, Parker, and Jones, 1888, and the genus must therefore be credited to Thalmann.

Cushman (1948, p. 335) and Bermudez (1952, p. 87) both erroneously cite *Cibicidoides eriksdalensis* Brotzen as type species and credit the genus itself to Brotzen, 1936. Sigal *in* Piveteau (1952, p. 229) cites the genus as *Cibicidoides* Brotzen, 1942, and figures *C. eriksdalensis,* although not definitely citing it as type species.

ALANWOODIA Loeblich and Tappan, new genus

Plate 4, figures 7, 8

Type species.—*Patellina campanaeformis* Brady, Rep. voyage *Challenger,* vol. 9 (Zoology), p. 634, text figs. 19a-c, 1884.

Derivation.—Patronymic. Gender, feminine.

Diagnosis.—Test free, conical, high-spired, ventrally flattened or slightly excavated, consisting of a proloculus and long, undivided, broad and low tubular chamber in a high, open conical spire, the central area being filled with clear or laminated calcite, tiny pores around the exterior spiral suture, wall calcareous, with the test composed of a single crystal of calcite; aperture ventral, at the open end of the spiraling tube.

Types.—Holotype (sectioned specimen, fig. 8), B.M.N.H. No. ZF 2065, is that figured by Brady in text figure 19c, p. 635, from *Challenger* station 185, off Raine Island, Torres Strait, at 155 fathoms. Paratype (exterior figured, fig. 7), B.M.N.H. No. ZF 3614, from the same locality and the specimen figured by Brady, 1884, text figures 19a,b, p. 635.

Discussion.—Describing it as a species of *Patellina,* Brady stated that the species appeared to be biserial at least in part, but that the last whorls were apparently undivided. A careful examination showed no septation, and this form differs from *Patellina* in having a broad and low undivided tube rather than a biserial series of chambers, in being extremely high-spired, and in having the central portion filled with calcite. There are faint transverse undulations of the ventral surface but no internal secondary septa as in *Patellina.* It is closer, perhaps, to *Trocholina* Paalzow, 1922, although the central filling is not in the

form of vertical pillars ending in pustules as in *Trocholina,* but consists of horizontally laminated structure. It also shows superficial resemblance to *Howchinia* Cushman, 1927, in the nonseptate tube coiled in a high spire about a calcite-filled center; however, *Howchinia* shows extensions of shell matter crossing the spiral suture, leaving a series of pores between, which extend into the interior. Furthermore, there is less of an open spiraling in *Howchinia* and its wall structure is of minutely granular calcite, not formed of a single crystal as in the present form, as was shown by Wood (1949, p. 245).

We have named this genus in honor of Prof. Alan Wood of Aberysthwyth, Wales, in recognition of his excellent work on the wall structures of Foraminifera, which has supplied an additional useful tool for the systematics of the Foraminifera.

Family CARTERINIDAE Loeblich and Tappan, new family

Test free or attached, chambers arranged in a trochoid coil, all visible from the dorsal side and only those of the last whorl on the ventral side, and may have subdivisions of the chambers due to secondary septa; wall composed of secreted calcareous spicules embedded in a calcareous ground mass; aperture in free forms ventral in position, in attached forms not observed.

Discussion.—This family is erected to include the genus *Carterina* because of the unique wall character. This is the only form as yet known to have a test composed of calcareous spicules secreted by the animal itself.

Genus CARTERINA Brady, 1884, emended

Plate 4, figures 9, 10

Original description.—Rep. voyage *Challenger,* vol. 9 (Zoology), pt. 22, pp. 66, 345, 1884.

Type species.—*Rotalia spiculotesta* Carter, 1877. Original designation.

Diagnosis.—Test free, trochoid and ventrally umbilicate in the early stages, attached and spreading irregularly in the later stages; chambers arranged in a trochoid coil, with five per whorl in the young, with the crescentic chambers of approximately equal height throughout, becoming much more irregular and longer in later whorls, chambers fewer in later whorls, only three to four, and these appear extremely low and long, and in a very irregular spiral; in the later stages the test is surrounded by a wide flangelike and undivided portion, which spreads over the surface of the substratum; sutures distinct, thickened, oblique

dorsally and slightly depressed, radial ventrally; beginning in the third whorl the chambers are subdivided by partial secondary septa coming in from the outer wall, at first only as minor projections, but in the later chambers becoming almost complete partitions, secondary septa also thickened and perpendicular to outer wall, not oblique dorsally as are the true septa, secondary septa not visible dorsally except when specimen is dampened, but slightly depressed on the ventral side of the free specimens (fig. 10b), the earlier chambers having only two or three of these secondary septa, but after the third whorl they increase in number per chamber as the chambers increase in relative length, leaving the chamberlets all of approximately equal size, and thus there may be as many as 15 subdivisions in the later chambers; wall thin, composed of calcareous spicules (secreted by the protoplasm) frequently aligned parallel to the periphery of the test, embedded in a calcareous areolated ground mass; aperture not observed in attached specimens, ventral in free specimens.

Types.—The holotype of Carter was from the Recent, East Oceania, Pacific Ocean. A prolonged search in the British Museum in London produced no trace of the type specimen. A specimen was found in the M.N.H.N., Paris, mounted on a slide of Carter's, and apparently sent by him to a French colleague. This specimen is here figured (fig. 9) and is from Bass Rock, Ceylon. The slide has the number 26.9.79, thus giving the date of identification as 2 years after the original description. The specimen from the Recent at Port Gaura, Philippines (figs. 10a-c) is in the U.S.N.M. (No. P 2201).

Discussion.—This genus, like many others, seems to have been better understood by Brady than by many later workers. Originally monotypic, only the species *Rotalia spiculotesta* Carter was known by Brady. Both Carter's original definition (1877b) and that of Brady clearly state that the wall is composed of numerous fusiform calcareous spicules, with interstitial material calcareous and areolated. Carter mentioned that the spicules increase in size from the most minute of the early chambers to attain a maximum size in the third whorl, beyond which they do not increase further.

Brady stated further that "it is obvious that the presence of spicula, not collected from external sources for the construction of the test, but proper to the animal itself, is a character of more than specific significance." It was thus on the basis of the secreted calcareous spicules that he separated *Carterina* as a genus distinct from *Rotalia*.

Later authors apparently lost sight of this and assigned the genus to the Trochamminidae (Flint, 1899, p. 260; Galloway, 1933, p. 183;

Cushman, 1940, p. 204). Other treatises do not mention the genus at all (Colom, 1946; Glaessner, 1948, Pokorný, 1954).

It remained for Wood (1949, p. 245) to call attention again to the unique character of this species. He mentioned that "each of the elliptical spicules which form its test is a single crystal of calcite. . . Each crystal lies with its *c*-axis parallel to the length of the spicule. It seems extremely probable that these spicules are a direct secretion of the protoplasm, they appear to be usually larger in the larger specimens, and nothing identical in form is known in any other animal." He also suggested the interesting hypothesis that because of its completely distinctive wall character *Carterina* is undoubtedly a recent offshoot and "might in the future give rise to a whole galaxy of new types," perhaps eventually as distinctive as the Porcellanea.

A feature of *Carterina* which has apparently escaped the observation of all workers is the subdivision of the chambers by secondary septa. This is not usually apparent from the dorsal exterior (fig. 10a), but when the specimen is dampened, the septa can be very easily seen through the thin wall (figs. 9a,b) and their development can be determined. On young free specimens the secondary septa are visible externally on the ventral side (fig. 10b). The earliest chambers are not subdivided, then only two or three subdivisions occur per chamber, and the early secondary septa consist of slight projections from the outer wall. With progressive growth the later chambers have more numerous partitions, up to as many as 15 per chamber, and the partitions are nearly complete, extending nearly or completely across the chambers. These subdivisions can be easily distinguished dorsally from the regular septa, as the true septa are oblique, the chambers crescentic, and the secondary partitions perpendicular to the peripheral wall.

As far as is known this genus is monotypic. Only one species other than the type species has been referred to *Carterina, C. fulva* Cushman (1924, p. 10) and Cushman and Wickenden (1929, p. 5), but the latter is a *Trochammina*-like form and agglutinated, not formed of calcareous spicules secreted by the organism itself, and thus completely different from *Carterina.*

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EXPLANATION OF PLATES

PLATE I. *Brachysiphon, Proteonina, Textularioides, Planctostoma, Jullienella,* and *Miliammina*

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Fig. 1. *Brachysiphon corbuliformis* Chapman 7

1a, Side view. 1b, Top view of topotype (B.M.N.H. No. ZF 3572), from off Great Barrier Islands, New Zealand. × 20.

Figs. 2, 3. *Reophax fusiformis* (Williamson) 7

2, Side view of lectotype of *Proteonina fusiformis* Williamson (B.M.N.H. No. ZF 3605), showing distinctly chambered test of the type species of *Proteonina,* proving it to be a synonym of *Reophax.* 3a, Side view of paratype (B.M.N.H. No. 96.8.13.1). 3b, Top view. This paratype is the specimen figured by Williamson (1858, pl. 1, fig. 1). Both from Recent sands from Skye. × 36.

Figs. 4, 5. *Textularioides inflata* Cushman 11

4a, Side view of topotype (U.S.N.M. No. P 2196a), showing attached early portion with later part growing free from the attachment. 4b, Top view, showing typical low, slitlike aperture. 5, Attached side of a topotype (U.S.N.M. No. P 2196b), showing radial structure of the agglutinated wall, with fine perforations through the wall. Both from *Albatross* station D 4900, in 139 fathoms off the coast of Japan. × 25.

Figs. 6-12. *Planctostoma luculentum* (Brady) 8

6a, Side view. 6b, Edge view of completely textularian hypotype with aperture at the base of the final chamber (U.S.N.M. No. P 2191), from Johnson-Smithsonian Expedition station 93. 7, Bigenerine hypotype (U.S.N.M. No. P 2193a), showing later chambers uniserial and aperture terminal and central, from *Challenger* station 23, off Sombrero Island, West Indies. 8a, Side view of typical biserial hypotype with nearly terminal aperture, rather than at the base of the last chamber. 8b, Edge view (U.S.N.M. No. P 2185), from *Albatross* station D 2150. 9, Side view of larger hypotype with final chamber tending to become central and with almost terminal aperture (U.S.N.M. No. P 2193b), from *Challenger* station 23. 10a, Side view of biserial hypotype, showing numerous subterminal apertures. 10b, Top view, showing the rare multiple aperture (U.S.N.M. No. P 2188), from *Challenger* station 24, Culebra Island, West Indies. 11a, Side view of broken bigenerine hypotype showing a single terminal chamber. 11b, Top view showing eccentric terminal aperture (U.S.N.M. No. P 2195a), from *Albatross* station D 2659. 12a, Side view of biserial hypotype (U.S.N.M. No. P 2195b). 12b, Top view, from *Albatross* station D 2659. All figures × 17.

Figs. 13, 14. *Jullienella foetida* Schlumberger 11

13, Topotype, collection of the Sorbonne, Paris, showing large flabelliform test, concentric growth ridges, and numerous rounded apertures at the ends of tubular extensions. × 1.5 14a, Enlarged view of surface of fragment of topotype, showing the growth ridges. 14b, Enlarged view of interior of fragment of topotype, showing the discontinuous radial ridges which subdivide the interior but are not reflected externally, and the numerous large pores leading toward the surfaces of the test. × 7.7. Topotype from bank of Poor River, coast of Liberia.

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Figs. 15, 16. *Miliammina earlandi* Loeblich and Tappan, new name........ 12

15a,b, Opposite sides of lectotype (B.M.N.H. No. ZF 3406). 15c, Top view, from R.R.S. *William Scoresby* station 43, off South Georgia. 16, Transverse section of hypotype (B.M.N.H. No. ZF 3407), from R.R.S. *William Scoresby* station 50, off South Georgia, showing definite quinqueloculine plan. These specimens were originally placed by Heron-Allen and Earland in *Miliammina arenacea* (Chapman) and then in *Miliammina oblonga* Heron-Allen and Earland, (not Montagu). All figures × 79.

Figs. 1-3, 14-16 are camera lucida drawings by Helen Tappan Loeblich; figs. 4-12 are camera lucida drawings by Lawrence Isham; fig. 13 is a photograph prepared for the writers by the Bureau des Recherches Géologiques et Géophysiques, Paris.

PLATE 2. *Trilocularena, Hauerina,* and *Involvohauerina*

Fig. 1. *Trilocularena circularis* (Heron-Allen and Earland)............. 13

1a,b, Opposite sides. 1c, Top view of lectotype (B.M.N.H. No. ZF 3563), from *Discovery* station D 182, Schollaert Channel, Palmer Archipelago, Antarctica. × 27.

Fig. 2. *Hauerina compressa* d'Orbigny................................ 14

2a, Side view of holotype (M.N.H.N.), from the Miocene of the Vienna Basin, showing somewhat evolute test. 2b, Edge view, showing lenticular form, acute periphery, and multiple aperture in a trematophore. × 58.

Figs. 3-8. *Involvohauerina globularis* Loeblich and Tappan, new genus, new species 14

3a, Side view of holotype (U.S.N.M. No. P 2202), showing subglobular involutely coiled three-chambered form. 3b, Edge view, showing broadly rounded periphery, and multiple aperture of irregular openings which are not restricted to a definite trematophore. 4, Dissected paratype (U.S.N.M. No. P 2203a), showing quinqueloculine early chamber arrangement, followed by planispiral arrangement with three chambers to a coil. 5, Edge view of paratype (U.S.N.M. No. P 2203b), showing slightly asymmetric coiling of young specimens. 6, Edge view of paratype (U.S.N.M. No. P 2203c), a more typical symmetrical form. 7, Edge view of asymmetrical young specimen (U.S.N.M. No. P 2203d). Figs. 3-7 from *Albatross* station D 2035. 8a,b, Opposite sides of large paratype (U.S.N.M. No. P 2204), the only specimen found in which four chambers are visible externally. 8c, Edge view showing symmetrically placed aperture, and later planispiral coiling. From *Albatross* station D 2859. All figures × 20.

All figures are camera lucida drawings; figs. 1, 2 by Helen Tappan Loeblich; figs. 3-8 by Lawrence Isham.

PLATE 3. *Polysegmentina, Rotaliammina, Tritaxis, Trochamminella, Rimulina, Bdelloidina,* and *Tubinella*

Figs. 1-3. *Polysegmentina circinata* (Brady)............................ 16

1a, Side view of lectotype (B.M.N.H. No. ZF 3629), showing only

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partially evolute coil, and sutural pores which connect with the interior. 1b, Edge view, showing numerous irregular pores in a trematophore. From *Challenger* station 187A, off Booby Island. × 48. 2a, Equatorial section of hypotype (U.S.N.M. P 2197b), showing early milioline chambers and perforated trematophore. × 48. 2b, Enlarged central portion of same equatorial section, showing trematophore distinct from the other test walls. × 109. 3a, Axial section of hypotype (U.S.N.M. No. P 2197a), showing early milioline chamber arrangement, with later planispiral coiling. × 48. 3b, Enlarged central portion of same axial section, showing extension of chamber wall over umbonal region, which obscures the early coiling on the exterior. × 109. Sectioned specimens from Torres Strait.

Fig. 4. *Rotaliammina mayori* Cushman 20

4a, Dorsal view of holotype (U.S.N.M. Cushman Coll. No. 511), showing trochoid nature, and chambers completely in contact, and with distinct, depressed sutures. 4b, Ventral view, showing central umbilicus and the somewhat collapsed chambers of the final whorl. 4c, Edge view. From near Pago Pago Harbor, Tutuila, Samoa. × 168.

Figs. 5, 6. *Tritaxis fusca* (Williamson) 19

5a, Dorsal view of hypotype (U.S.N.M. No. P 2198a), showing crescentic later chambers, with early chambers nearly globular. 5b, Ventral view, showing ovate aperture with distinct lip, above the base of the final chamber, and near the center of the flattened ventral side. 5c, Edge view, showing low conical spire. 6, Dorsal view of attached hypotype (U.S.N.M. No. P 2198b), showing low conical form attached ventrally and surrounded by an irregular spreading mass of agglutinated material. Both from F. C. *Helga* Haul SR 331, off southwestern Ireland. × 36.

Fig. 7. *Tritaxis siphonifera* (Cushman) 20

View of holotype (U.S.N.M. Cushman Coll. No. 39619) of the type species of *Trochamminella,* showing it to be congeneric with *Tritaxis,* consisting of planoconvex test with crescentic chambers, surrounded by agglutinated rim, extending at one side into tubular protrusion terminating in a rounded aperture. × 33. From Johnson-Smithsonian Expedition station 25, off Puerto Rico.

Fig. 8. *Rimulina glabra* d'Orbigny 22

8a, Side view of holotype (M.N.H.N.), showing elongate-ovate outline. 8b, Edge view, showing elongate slitlike aperture surrounded by a lip, and absence of distinct septa. Recent of the Adriatic Sea. × 58.

Figs. 9, 10. *Bdelloidina aggregata* Carter 21

9a, Side view of attached and branching hypotype (U.S.N.M. No. P 2199), from the Indian Ocean. 9b, Top view showing aperture consisting of a row of pores against the attachment on the terminal chamber. × 4. 10a, Much-branched hypotype (U.S.N.M. No. P 2200), from surface of a coral, Namu Island, Bikini Atoll. × 35. 10b, Apertural view of one branch, showing two rows of pores. × 15.

Figs. 11, 12. *Tubinella inornata* (Brady) 18

11, Small paratype (B.M.N.H.) viewed by transmitted light, and showing the vestigial milioline stage consisting of proloculus and closely appressed second chamber, reversing the direction of growth, and the

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vestigial septa, consisting of transverse wall thickenings. $\times$ 79. 12, Side view of lectotype (B.M.N.H. No. ZF 3656), showing elongate tubular appearance. $\times$ 36. From *Challenger* station 149 D, Balfour Bay, Kerguelen Island.

All figures are camera lucida drawings; figs. 1-3, 8, 11-12 by Helen Tappan Loeblich; figs. 4-7, 9-10 by Lawrence Isham.

PLATE 4. *Orthoplecta, Schubertia, Cibicidoides, Monalysidium, Webbina, Alanwoodia,* and *Carterina*

Figs. 1, 2. *Orthoplecta clavata* Brady 24

1a, Side view of holotype (B.M.N.H. No. ZF 2064), showing elongate, arcuate test, very irregular septa and subterminal ovate aperture, adjacent to sutural junction. 1b, Top view. From *Challenger* station 219A, Admiralty Islands. 2, Dissected hypotype (B.M.N.H. No. ZF 3630), showing spiraling internal column, which gives the irregular appearing septation where it touches the outer wall. From *Challenger* station 185, off Raine Island, Torres Strait. $\times$ 109.

Fig. 3. *Schubertia tessellata* (Brady) 24

3a, Side view of lectotype (B.M.N.H. No. ZF 2359), showing early biserial stage, followed by a single undivided uniserial chamber and later uniserial chambers subdivided into honeycomblike chamberlets. 3b, Top view showing circular terminal aperture, surrounded by a slight lip. $\times$ 109. From *Challenger* station 219A, Admiralty Islands.

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Fig. 5. *Monalysidium sollasi* Chapman 23

5a, Side view of holotype (B.M.N.H. No. ZF 3577), from beach at Avalau Island, Funafuti Atoll, showing subglobular chambers, at first in a planispiral coil and later rectilinear, and aperture produced on a neck with a phialine fimbriate lip. 5b, Edge view. $\times$ 79.

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6a, Dorsal view of holotype (M.N.H.N.), showing ovate chambers with fimbriate keel, and rounded terminal aperture. 6b, Ventral view, showing attached side. From Recent, l'Île de Ténériffe, Îles Canaries. $\times$ 58.

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7a, Dorsal view of paratype (B.M.N.H. No. ZF 3614), showing proloculus and undivided second chamber. 7b, Ventral view, showing filled umbilical region, and transverse wrinkles of the undivided chamber. 7c, Edge view, showing undivided spiraling chamber and minute pores

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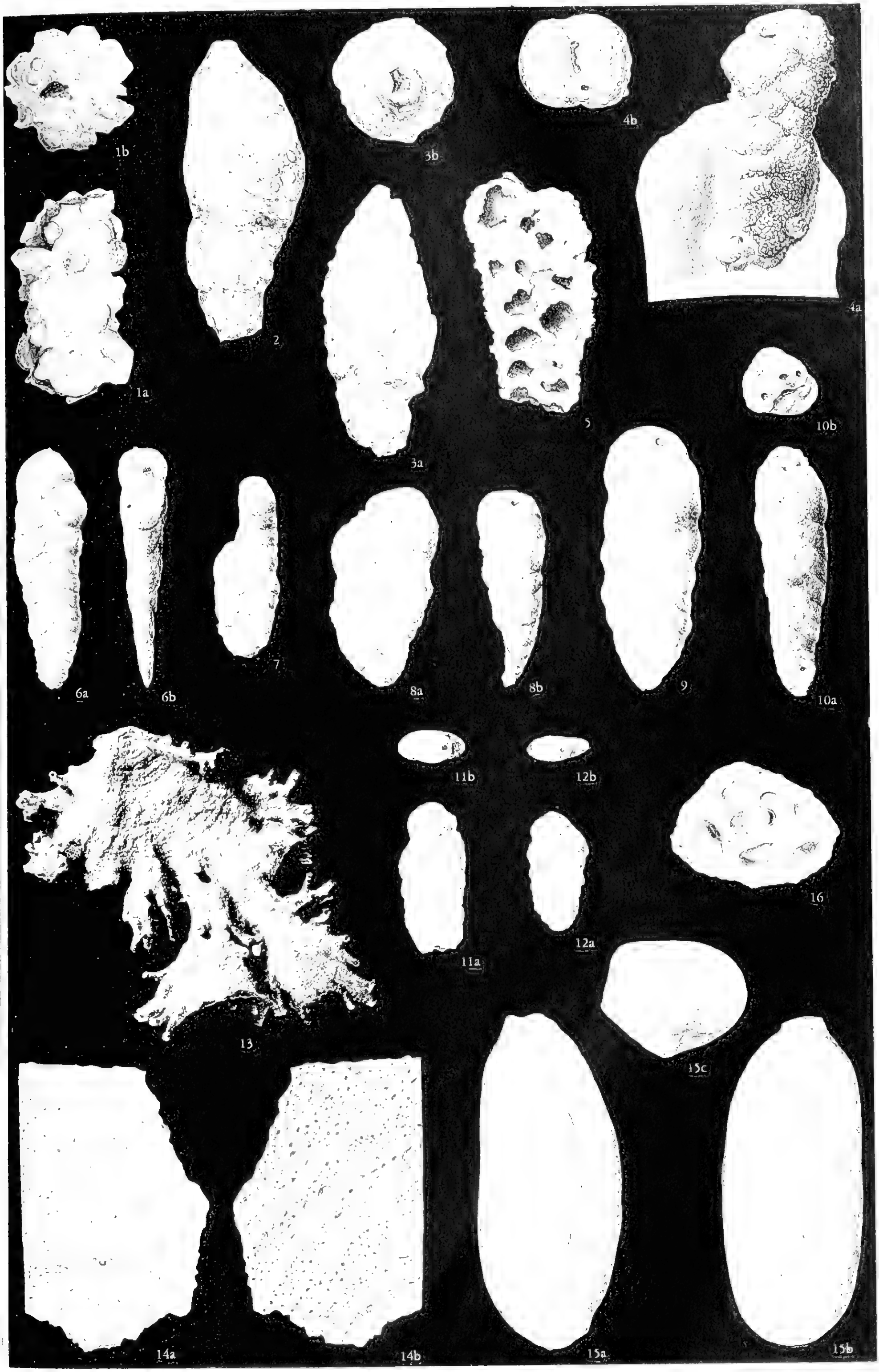
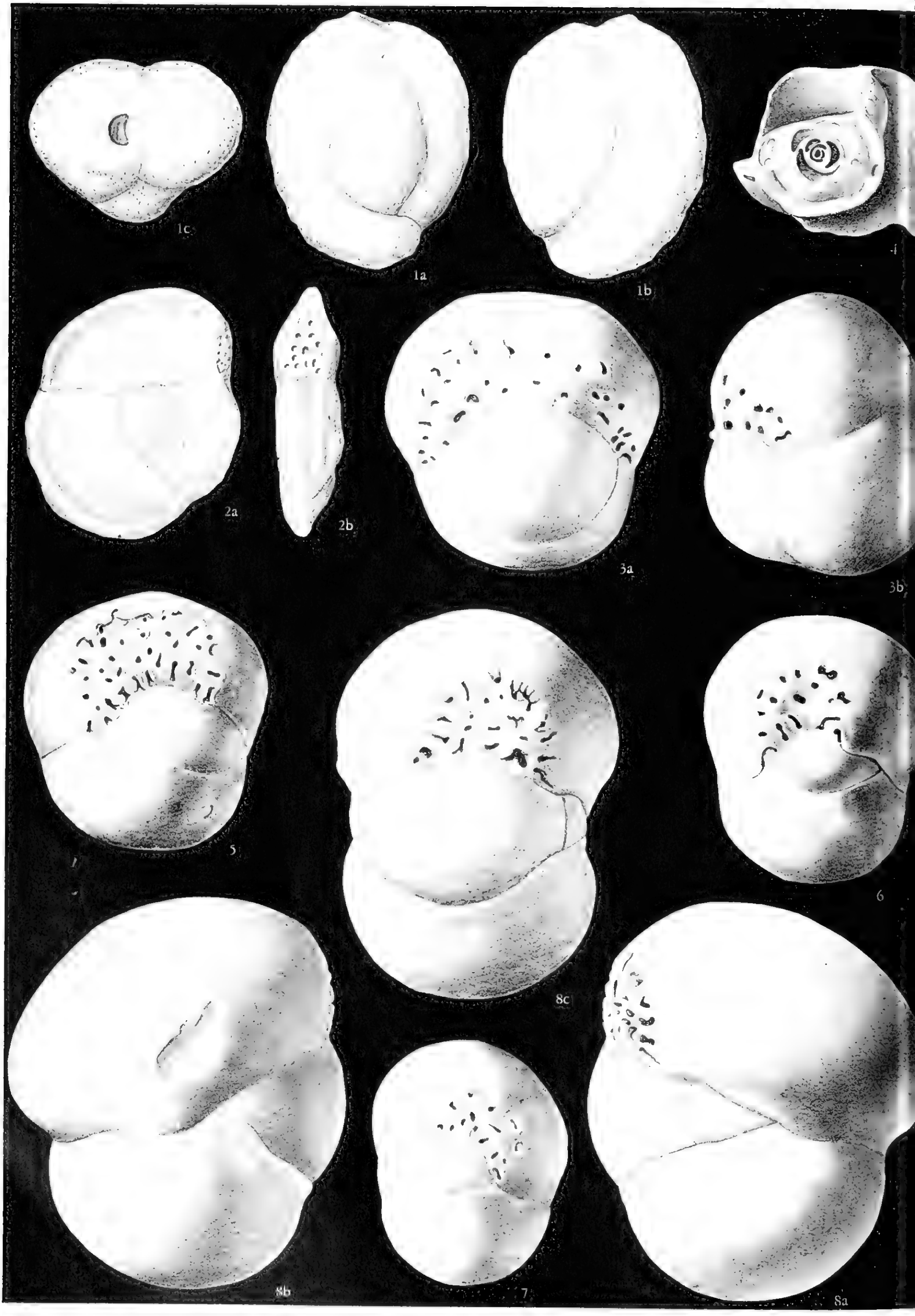
Figs. 9, 10. *Carterina spiculotesta* (Carter) 27

9a, Dorsal view of large hypotype (specimen of Carter in M.N.H.N.), showing early *Discorbis*-like coil and later irregularly arranged crescentic, low and broad chambers, all subdivided by radial partitions visible only when specimen is dampened, and surrounded by a spreading attached portion which is undivided, the entire test composed of fusiform calcareous spicules. × 21. 9b, Central portion of same specimen, enlarged to show early chamber development, arrangement of the calcareous spicules, and the gradual development of the radial partitions, from 2 only partial secondary septa in the third whorl chambers to as many as 15 complete subdivisions in the later elongate cresentic chambers. From Bass Rock, Ceylon. × 79. 10a, Dorsal view of hypotype (U.S.N.M. No. P 2201), a young form, showing the typical appearance before becoming attached in the later stage, with only five chambers in the final whorl, and showing the appearance of a dry specimen with the secondary partitions invisible dorsally. 10b, Ventral view, showing open umbilicus, radial sutures, and the slightly depressed secondary septa, which can be determined surficially and are scarcely separable ventrally from the five true septa. 10c, Edge view, showing low spire and rounded periphery. × 60. From Recent at Port Gaura, Philippines.

All figures are camera lucida drawings; figs. 1-9 by Helen Tappan Loeblich; fig. 10 by Lawrence Isham.



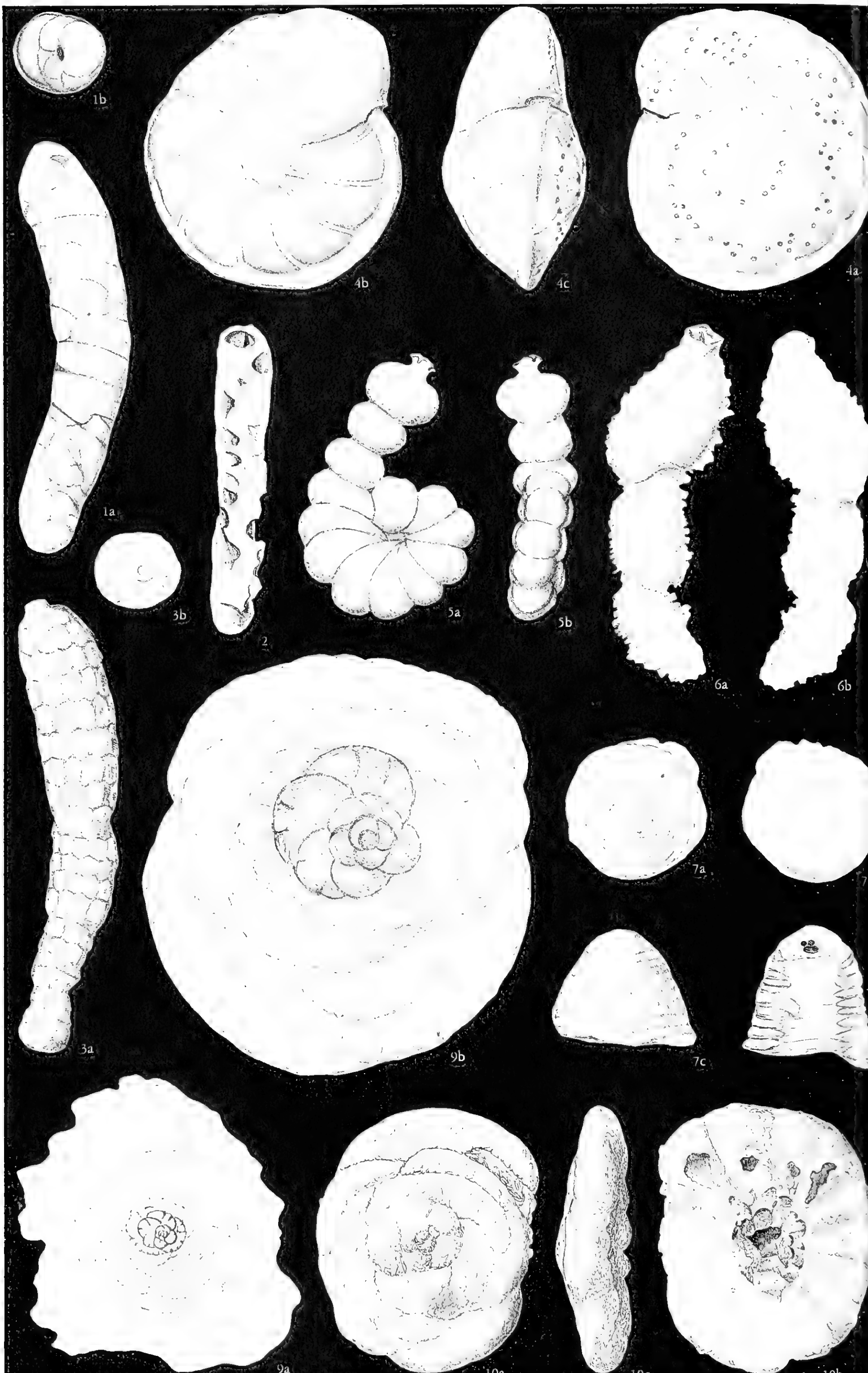
BRACHYSIPHON, PROTEONINA, TEXTULARIOIDES,
PLANCTOSTOMA, JULLIENELLA, AND MILIAMMINA



TRILOCULARENA, HAUERINA, AND INVOLVOHAUERINA

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

POLYSEGMENTINA, ROTALIAMMINA, TRITAXIS, TROCHAMMINELLA, RIMULINA, BDELLOIDINA, AND TUBINELLA



ORTHOPLECTA, SCHUBERTIA, CIBICIDOIDES, MONALYSIDIUM,

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A REVISION OF THE CHIGGERS OF THE SUBGENUS GAHRLIEPIA (ACARINA: TROMBICULIDAE)

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CONTENTS

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INTRODUCTION

The chiggers parasitic on small mammals have been attracting considerable attention during recent years because of their potentialities as vectors of disease. The chigger fauna is nevertheless relatively little known, as is indicated by the fact that 18 of the 33 mites of the subgenus *Gahrliepia* discussed in this paper are new to science. In southeast Asia the *Gahrliepia* complex is rich in numbers of species, but individuals are not as commonly collected as are trombiculids of the genera *Trombicula* Berlese, 1905, and *Euschöngastia* Ewing, 1938. However, there is reason to believe that the relative scarcity of individuals may perhaps be apparent rather than actual. For example, one of the new species described herein was found to burrow completely into the perineum of the host and thus very easily could have been overlooked. A second *Gahrliepia* was "rare" until it was observed that this species had unusual but specific areas of attachment.

The current study is based largely upon material collected in Malaya and Borneo by field teams of the U. S. Medical Research Unit (Malaya)[1] and the Colonial Office Medical Research Unit, both headquartered at the Institute for Medical Research, Kuala Lumpur, and upon the wartime collections of the India-Burma Field Party of the United States of America Typhus Commission. Thanks to the activities of the U. S. Special Technical and Economic Mission to Thailand, some Siamese specimens have also been made available for study.

[1] Supported in part by the Medical Research and Development Division, Office of the Surgeon General, Department of the Army.

This revision commences with a discussion of the taxonomic status of the subgenus *Gahrliepia,* and there then follow descriptions of new species. The first such species is characterized in detail, and in the subsequent descriptions only the important differences from the first are stressed. The known species are then diagnosed and discussed. A key for the identification of all 33 species precedes some general taxonomic notes and comments on the hosts and habitats of the subgenus. The new *Gahrliepia* are illustrated in detail, as are the genotype and some of the other important species. The remaining forms are illustrated insofar as possible or necessary for the purposes of the key. It was felt that this paper would be most useful if it were made revisionary in nature and if all described species were included even though it was impossible to examine specimens of all the known forms. It was necessary to rely wholly on the literature or unpublished notes [2] for the discussion and illustrations of the following species: *crocidura* (Radford, 1946), *hirsuta* (Radford, 1946), *longipili* (Radford, 1946), *romeri* Womersley, 1952, *spinulosa* (Radford, 1946), *lancearia* (Radford, 1946), *ciliata* Gater, 1932, *lawrencei* Jadin and Vercammen-Grandjean, 1952, and *philipi* (Jadin and Vercammen-Grandjean, 1952).

TAXONOMIC STATUS OF THE SUBGENUS *GAHRLIEPIA*

There is considerable confusion in the literature as to what species should be included in the genus *Gahrliepia.* Mainly for convenience we are considering *Walchia* Ewing (1931) and *Schöngastiella* Hirst (1915) as subgenera of *Gahrliepia,* and the species therein are dealt with elsewhere (Traub and Evans, 1954, and MS.). However, for reasons discussed below, *Gateria* Ewing, 1938, is treated as an outright synonym of *Gahrliepia* (*Gahrliepia*). The taxonomic and bibliographic citations for the subgenus *Gahrliepia* are therefore as follows:

GAHRLIEPIA (GAHRLIEPIA) Oudemans, 1912

Genotype: *Typhlothrombium nanus* Oudemans, 1910, by original designation.

1910. *Typhlothrombium* Oudemans, Ent. Ber. Amsterdam, vol. 3, No. 56, p. 105.
1912. *Typhlothrombium* Oudemans, Oudemans, Zool. Jahrb., Suppl., vol. 14, No. 1, p. 83.

[2] Dr. H. S. Fuller and Dr. J. R. Audy kindly allowed us access to manuscript notes each had independently prepared during a study of type specimens at the British Museum.

1912. *Typhlothrombium* OUDEMANS, Berlese, Redia, vol. 8, p. 281 (preoccupied by *Typhlothrombium* Berlese, July 8, 1910).
1912. *Gahrliepia* OUDEMANS, Ent. Ber. Amsterdam, vol. 3, No. 67, p. 273; *nomen novum* for *Typhlothrombium* Oudemans, November 1, 1910, preoccupied.
1928. *Typhlothrombium* OUDEMANS, Methlagl, Denkschr. Akad. Wiss. Wien., vol. 101, p. 214.
1928. *Typhlothrombidium* OUDEMANS, Treubia, 8th suppl., p. 91; *nomen novum* for *Typhlothrombium* Oudemans, November 1, 1910, preoccupied.
1931. *Gahrliepia* OUDEMANS, Vitzthum, Kükenthal's Handbuch der Zoologie, vol. 3, 2d half, No. 9, pp. 48, 63, 146.
1932. *Gahrliepia* OUDEMANS, Gater, Parasitol., vol. 24, No. 2, p. 161 (equals *Typhlothrombium* Oudemans, 1910, and *Schöngastiella* Hirst, 1915, synonyms).
1935. *Gahrliepia* OUDEMANS, Sig Thor, Zool. Anz., vol. 109, Nos. 5-6, p. 110.
1937. *Gahrliepia* OUDEMANS, Womersley, Rec. South Australia Mus., vol. 6, No. 1, p. 79.
1938. *Gahrliepia* OUDEMANS, Ewing, Journ. Washington Acad. Sci., vol. 28, No. 6, pp. 291, 292.
1938. *Gateria* EWING, Ewing, op. cit., pp. 291-295.
1939. *Gahrliepia* OUDEMANS, Neave, Nomenclator Zoologicus, vol. 2, p. 431.
1939. *Gahrliepia* OUDEMANS, Abdussalam, Indian Journ. Ent., vol. 1, No. 3, pp. 84-85.
1940. *Typhlothrombium* OUDEMANS, Neave, Nomenclator Zoologicus, vol. 4, p. 602 (preoccupied; synonym of *Gahrliepia* Oudemans, 1912).
1940. *Gahrliepia* OUDEMANS, Gunther, Proc. Linn. Soc. New South Wales, vol. 65, parts 5-6, Nos. 291-292, p. 481 (equals *Typhlothrombium* Oudemans, 1910, and *Schöngastiella* Hirst, 1915, synonyms).
1941. *Gahrliepia* OUDEMANS, Vitzthum, Bronn's Klassen und Ordnungen des Tierreichs, Bd. 5, Abt. IV, Buch 5, Lfg. 4, p. 624.
1942. *Gahrliepia* OUDEMANS, Vitzthum, op. cit., Lfg. 6, p. 829 (equals *Typhlothrombium* Oudemans, 1910, preoccupied).
1942. *Gateria* EWING, Vitzthum, Bronn's Klassen und Ordnungen des Tierreichs, Bd. 5, Abt. IV, Buch 5, Lfg. 6, p. 829.
1942. *Gahrliepia* OUDEMANS, Radford, Parasitol., vol. 34, No. 1, pp. 64, 79.
1942. *Gateria* EWING, Radford, op. cit., p. 67.
1943. *Gahrliepia* OUDEMANS, Womersley and Heaslip, Trans. Roy. Soc. South Australia, vol. 67, No. 1, pp. 72, 136-137 (equals *Typhlothrombium* Oudemans, 1910; *Schöngastiella* Hirst, 1915; and *Gateria* Ewing, 1938, synonyms).
1944. *Gahrliepia* OUDEMANS, Ewing, Journ. Parasitol., vol. 30, No. 6, p. 348.
1944. *Gateria* EWING, Ewing, ibid.
1945. *Gahrliepia* OUDEMANS, Finnegan, British Mus. (Nat. Hist.), Econ. Ser., No. 16, pp. 14, 57, 75 (equals *Schöngastiella* Hirst, 1915, and *Gateria* Ewing, 1938, synonyms).
1946. *Gahrliepia* OUDEMANS, Taylor, Comm. Australia Serv. Publ. No. 6, p. 147 (equals *Schöngastiella* Hirst, 1915, and *Gateria* Ewing, 1938, synonyms).
1946. *Gahrliepia* OUDEMANS, Ewing, Journ. Parasitol., vol. 32, No. 5, p. 436.
1946. *Gateria* EWING, Ewing, ibid.
1946. *Gahrliepia* OUDEMANS, Radford, Proc. Zool. Soc. London, vol. 116, pt. 2, p. 247.

1946. *Gateria* Ewing, Radford, ibid.
1947. *Gahrliepia* Oudemans, Sig Thor and Willmann, Trombidiidae, Das Tierreich, Lfg. 71b, p. 332.
1947. *Gateria* Ewing, Sig Thor and Willmann, op. cit., pp. 338-339.
1948. *Gahrliepia* Oudemans, Fuller, Bull. Brooklyn Ent. Soc., vol. 43, No. 4, p. 109.
1948. *Gateria* Ewing, Fuller, op. cit., p. 110.
1949. *Gahrliepia* Oudemans, Ewing, Journ. Washington Acad. Sci., vol. 39, No. 7, p. 235.
1949. *Gateria* Ewing, Ewing, ibid.
1950. *Gahrliepia* Oudemans, Radford, Internat. Union Biol. Sci. (Paris), ser. C, No. 1, p. 98.
1950. *Gateria* Ewing, Radford, ibid.
1951. *Gahrliepia* Oudemans, Wharton et al., Journ. Parasitol., vol. 37, No. 1, p. 27.
1951. *Gateria* Ewing, Wharton et al., ibid.
1952. *Gahrliepia* Oudemans, Wharton and Fuller, Mem. Ent. Soc. Washington, No. 4, p. 93.
1952. *Gateria* Ewing, Wharton and Fuller, ibid.
1952. *Gahrliepia* Oudemans, Jameson, Keegan, and Toshioka, Parasitic mites found on small mammals in Japan and Korea, Office of the Surgeon, Far East Command (U.S. Army, Tokyo), p. 8.
1952. *Gahrliepia* (*Gahrliepia*) Oudemans, Womersley, Rec. South Australia Mus., vol. 10, Nos. 1-2, pp. 19, 22, 279-280, 282. (Considers *Walchia* Ewing, *Schöngastiella* Hirst, *Gateria* Ewing, all as subgenera of *Gahrliepia*.)
1952. *Gahrliepia* Oudemans, Gunther, Proc. Linn. Soc. New South Wales vol. 77, Nos. 1-2, p. 46.
1952. *Gahrliepia* Oudemans, Jadin and Vercammen-Grandjean, Ann. Soc. Belge Med. Trop., vol. 32, No. 6, p. 625.
1952. *Gateria* Ewing, Jadin and Vercammen-Grandjean, op. cit., p. 629.
1952. *Gahrliepia* Oudemans, Vercammen-Grandjean, Ann. Soc. Belge Med. Trop., vol. 32, No. 6, pp. 642-643.
1952. *Gateria* Ewing, Vercammen-Grandjean, ibid. (Questions validity of generic status of *Walchia, Schöngastiella,* and *Gateria* but treats them as distinct genera.)
1952. *Gahrliepia* Oudemans, Fuller, Zool. Verh., No. 18, pp. 212-213.
1952. *Gateria* Ewing, Fuller, op. cit., pp. 216-217.
1954. *Gahrliepia* (*Gahrliepia*) Oudemans, Sasa and Jameson, Proc. California Acad. Sci., ser. 4, vol. 28, No. 5, p. 250.

References in the literature concerning the comparative status of *Gateria* and *Gahrliepia* are reviewed by Womersley (1952) and Fuller (1952). The only criterion for separating the two genera is whether the dorsal setae which are usurped by the scutum are marginal or submedian in position. On this basis, only *nanus* Oudemans, 1910 (the genotype) and *cetrata* Gater, 1932, have been considered *Gahrliepia,* and the remaining eight described species have often been deemed *Gateria.* However, our examination of paratype material disclosed

that in *cetrata* the four false scutal setae (the usurped setae) were in reality submedian in position, not marginal. Gater's original figure (1932) is also incorrect insofar as the holotype is concerned, as Fuller (1952) points out, although Fuller made no nomenclatorial changes. Womersley (1952) and other authors, without access to type material, assumed Gater's drawing was correct. This means that only *nanus* remains in the genus *Gahrliepia* if the position of the usurped setae is a valid distinction. In our opinion, the character is a wholly superficial one and not even worthy of subgeneric rank. Those *Gahrliepia* with a scrobiculate ("ornate") scutum, i.e., one adorned with very large pits or scrobiculi (cf. fig. 94, scrobiculate, and fig. 5, nonscrobiculate), can be separated at a glance from the forms with a nonmodified scutum. It would seem that such a great morphological distinction would be a far superior criterion for grouping the species into genera than is the position of the usurped setae. However, six of the ornate species included in this paper would fall into *Gateria* and five into *Gahrliepia*. For these reasons, *Gateria* is considered by us to be synonym of the subgenus *Gahrliepia*. The subgenus *Gahrliepia* may be defined as follows: Gahrliepiine chiggers in which four or more dorsal abdominal setae have been usurped by the scutum so that there is at least a total of 8 scutal setae.[3] Scutum produced posteriorly beyond *PLs* (see list of abbreviations, below) so that *SD* is thrice or more than *A-P* (except for *G. saduski* Womersley, 1952). Galeal seta nude. Palpal coxal seta plumose. Palpal femoral seta usually barbed.

LIST OF ABBREVIATIONS

AL length[4] of anterolateral seta.
ALs the anterolateral setae.
A-P distance between bases of anterolateral and posterolateral setae.
A.P. anal plate.
ASB perpendicular distance between a line connecting sensillary bases and anteriormost margin of scutum.
AW distance between bases of anterolateral setae.
B symbol for a seta that is heavily branched or barbed.
b a seta that is sparsely branched, i.e., only 3 to 6 barbs.
C.C. central core, a rather dense patch of small scrobiculi in the middle of the scutum which differ from marginal scrobiculi.
D.S. length of typical dorsal seta.

[3] An occasional specimen of *G. saduski* has only 6 scutal setae. The presence of 4 or 5 setae on coxa III separates this species from all other *Gahrliepia* (*Gahrliepia*) and from all *G.* (*Schöngastiella*) except *G.* (*S.*) *kalrata* Traub and Evans 1954, which is readily distinguishable otherwise.

[4] All measurements expressed in microns.

f a seta that is merely frayed, i.e., with only 1 or 2 barbs.
FL dorsal flap extending posteriorly from cheliceral base.
I.C. intersensillary crater, a delimited circular area on the scutum, anterior to *SB* and between *ALs,* that is devoid of pits or punctae.
N a seta that is nude.
PL length of posterolateral seta.
PLs the posterolateral setae.
PPP-1 perpendicular distance between a line connecting first pair of usurped setae and posterior margin of scutum.
PPP-2 perpendicular distance between a line connecting second pair of usurped setae and posterior margin of scutum.
PPW-1 distance between first or anterior pair of usurped scutal setae.
PPW-2 distance between second or posterior pair of usurped scutal setae.
PSB perpendicular distance between a line connecting sensillary bases and posterior margin of scutum.
PW distance between bases of posterolateral setae.
SB distance between bases of sensillae.
SD length of *ASB* plus *PSB.*

DESCRIPTIONS OF SPECIES

GAHRLIEPIA (GAHRLIEPIA) EXILIS, new species

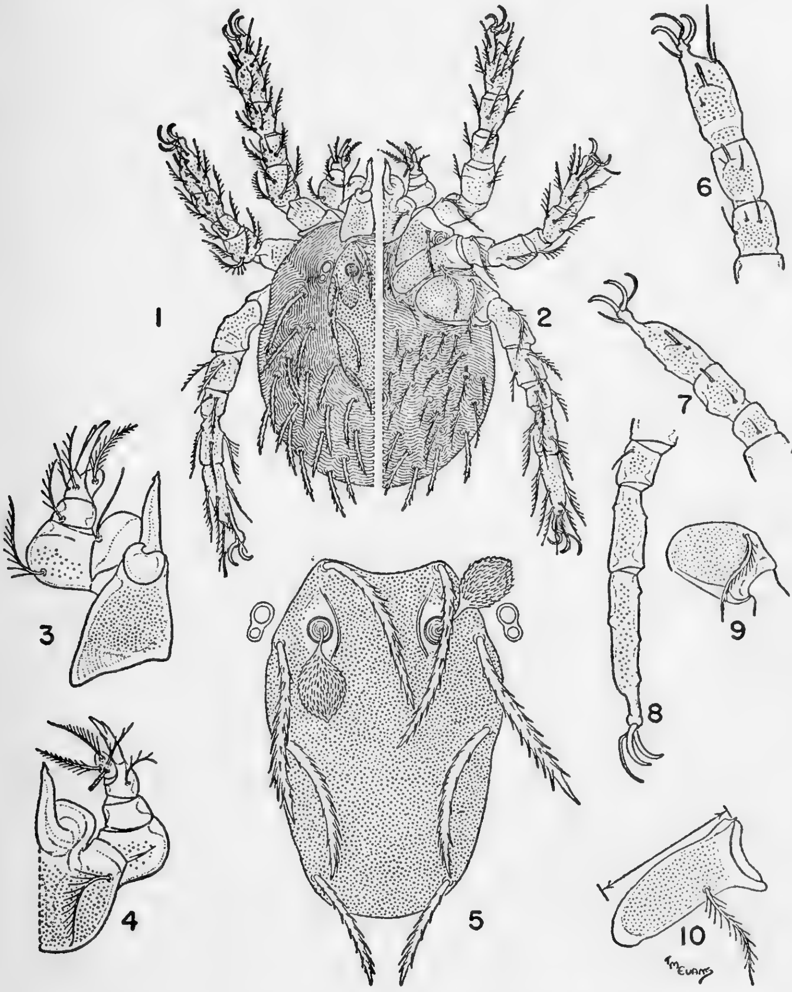
Figures 1-10

Diagnosis of larva.—Agrees with *G.* (*G.*) *cetrata* Gater, 1932, and *G.* (*G.*) *saduski* Womersley, 1952, in that the scutum lacks very large pits or scrobiculi and in having a total of 8 scutal setae (*G. saduski* somewhat variable in this regard). Instantly separable from both species in that the false or usurped scutal setae are marginal, not submedian; further distinguishable from *G. saduski* in that coxae III are 1-setose instead of bearing 4 setae; *AL* over 62 microns instead of approximately 35. The very long *AL* bristles also readily distinguish this species from *G. cetrata,* where the *ALs* are about 36 microns.

Description of larva.—*Body:* Subovate, about 244 x 155 microns when unengorged. Eyes double, anterior eye about 10 x 5 microns, about twice the size of the posterior one; on an ocular plate; at level of sensillary bases; plate near but not contiguous with scutum. *Gnathosoma:* Chelicerae long, about five to six times as long as broad at base; with a distinct apical tricuspid cap. Cheliceral bases and palpal coxae and femora punctate. Palpal setal formula as follows: *B/B/BBB,*[5] the setae (barbs) usually subpectinate. Palpal tarsus with a basal striated rod and four plumed setae. Palpal claw 3-pronged but usually

[5] The first letter in the palpal formula refers to the seta on the palpal femur, the second to that of the genu, and the next three to those of the tibia—dorsal, lateral, and ventral, respectively. The letter *N* in the palpal formula signifies the seta is nude; *B,* branched, *b,* sparsely branched; and *f,* frayed.

appearing 2-pronged, the mesal (dorsal) prong slightly the longest, the inconspicuous third prong about two-thirds the length of the others. *Scutum:* Long, broadly and evenly tongue-shaped; 120 x 84 microns



FIGS. 1-10.—*Gahrliepia (Gahrliepia) exilis,* new species.

at maxima in holotype. Anterior margin concave. Posterior margin evenly rounded. Lateral margins somewhat convex, broadest immediately below insertion of *PLs,* at times slightly angled here. Uniformly micropunctate, the micropunctations about 0.5 micron in size, all subequal. *AL* setae at anterolateral angles of scutum; bushy, long,

as long as *PLs*. Posterolateral setae marginal, inserted at a level somewhat caudad to bases of sensillae; similar to *ALs* in structure. The two pair of scutal setae usurped [6] from dorsal rows are marginal in position; first usurped pair as far from *PLs* as latter is from *ALs*, and resembling *PLs* but slightly shorter; second false pair of scutal setae near caudal margin of scutum, plumose, but only about 45 microns in length. With a distinct ridge anterior to each sensillary base. Sensillae ovate to subglobose; with distinct petiole; 31 (including petiole) x 17 microns. The mean distance in microns between the first (anteriormost) pair of usurped setae (*PPL-1*) is 72 (*PPW-1*), with a range of ±4. Mean distance between second pair of usurped setae (*PPL-2*) is 47 (*PPW-2*), ±5. Distance from first pair of usurped setae to posterior margin of scutum is 63 (*PPP-1*), ±3. Distance from *PPL-2* to posterior margin of scutum is 16 (*PPP-2*), ±2. *Body*

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype, U.S.A.T.C.[7] No. 750-14	39	72	38	24	96	30	67	67	40/57	72/58=1.24	0.60	3.0	72/72=1.00
Paratypes (28): Mean	40	73	39	26	101	30	69	69	49	1.24	0.57	2.8	0.99
Range + or —......	3	3	3	4	10	2	5	3	3	0.06	0.04	0.05	0.07

setae: Dorsal setae similar to scutal setae but shorter and somewhat less bushy, the pinnae not apparent for proximal fourth to sixth; about 32 in number excluding those captured by scutum; arranged 2.4(2).6(2).8.6.4.2 (the numbers in parentheses referring to the usurped setae). With about 46 to 48 ventral setae, of which 22 are postanals. True ventrals about 28 microns in length, thin, distinctly branched, but pinnae narrow. *Legs:* Coxae with ventral and dorsal margins distinctly punctate; legs punctate. Coxa III (fig. 9) in ratio of 61 (length) to 43 microns, viz, 1.41 (at maximal points). All coxae 1-setose, the setae long, thinly branched; in coxa I the seta is submedian; in coxa II (fig. 10, showing method of measuring length) ventromarginal; in III dorsomarginal, near apex. Sternal setae consisting of a pair of long (50 microns), thin setae inserted near midline about level with base of coxa I; a second pair of shorter bristles (30 microns), each member inserted near base of coxa III. Sensory

[6] The dorsal setae which arise directly from the dorsal plate by virtue of its posterior prolongation are henceforth referred to as *usurped setae*. The *Als* and *PLs* are therefore not usurped setae.

[7] Abbreviations accompanying specimen numbers throughout "Description of Species": U.S.A.T.C. = United States of America Typhus Commission; U.S.N.M. = U. S. National Museum; C.O.M.R.U. = Colonial Office Medical Research Unit; B = Traub accessions.

setae as follows: Leg I with two genualae and a microgenuala, a tibiala, a spur and an adjacent microtibiala; a tarsal spur, a microtarsala proximad of this, a subterminala, a parasubterminala, and a pretarsala. Leg II with a genuala; a tibiala and a spur; tarsus with a spur and microspur and a pretarsala. Leg III with only a genuala.

Type material.—Holotype and 40 paratypes (U.S.A.T.C. No. 750), ex *Rattus rattus sladeni* (Anderson) (attached to penis and perineum), North Burma, Shingbwiyang, March 7, 1945 (U. S. A. Typhus Commission). Other paratypes as follows: 40 ex the scrotum of another *Rattus rattus sladeni* (No. 751), ibid.;[8] 20 paratypes ex perineum (No. 753), ibid.; 12 (No. 756) ibid., but March 9; 40 ibid., but ex perineum and hindquarters of *Tupaia belangeri versurae* Thomas (No. 754), a tree shrew, March 8, 1945; 3, ibid., but ex *Rattus fulvescens fulvescens* (Gray), April 6. Holotype (U.S.N.M. No. 2154) deposited in collections of U. S. National Museum. Paratypes deposited in collections of U. S. National Museum; British Museum; Rocky Mountain Laboratory of the U. S. Public Health Service; South Australia Museum; Colonial Office Medical Research Unit at Kuala Lumpur; 406th Medical General Laboratory, U. S. Army, Tokyo; Army Medical Service Graduate School, Washington, D. C.; and those of E. W. Jameson, Jr., C. D. Radford, and the senior author, as well as in various other collections.

Comment.—*Gahrliepia* (*G.*) *exilis,* new species, is apparently particularly interesting for its seasonal and geographical distribution. Although the India-Burma Field Party of the U. S. A. Typhus Commission examined several thousand hosts from the Ledo, Assam area, and Shingbwiyang and Myitkyina in North Burma, this species, unlike many other chiggers, was collected only at Shingbwiyang. Ledo and Myitkyina were typical examples of secondary forest or scrub terrain, but Shingbwiyang was essentially all primary forest except where military camps had been constructed in the past 1 to 2 years. Here, moreover, *G. exilis* was exceptionally abundant in March (the height of the dry season), relatively uncommon in April, rare during the "little monsoon" rains in January and February, and apparently absent in June (the beginning of the rainy season) and in October (the end of the monsoon season). No collections were made at Shingbwiyang in other months. *G. exilis* is, therefore, apparently a characteristic inhabitant of primary forest during the dry season. It was collected on 12 occasions—nine times from *Rattus rattus sladeni,* twice

[8] In these descriptions, ibid. refers to the data for the holotype and not to the record immediately preceding. Only the differences in data between the particular paratype and holotype are cited.

ex *Rattus fulvescens fulvescens,* and once on a tree shrew, *Tupaia.* In March, whenever this species was found, it was the dominant form present on the host—four times out of five over 92 percent of the chiggers examined were *G. exilis.* The above *Tupaia* carried over 200 trombiculids, and all of 50 examined were *G. exilis.* In April, when *G. exilis* occurred, it usually constituted 20 to 30 percent of the chiggers sampled. The usual site of attachment of *G. exilis* was on the perineum or external genitalia of the host. This chigger did not readily detach from the host, and at times could be found firmly in situ 24 to 48 hours after death.

GAHRLIEPIA (GAHRLIEPIA) FIMBRIATA, new species

Figures 11-18

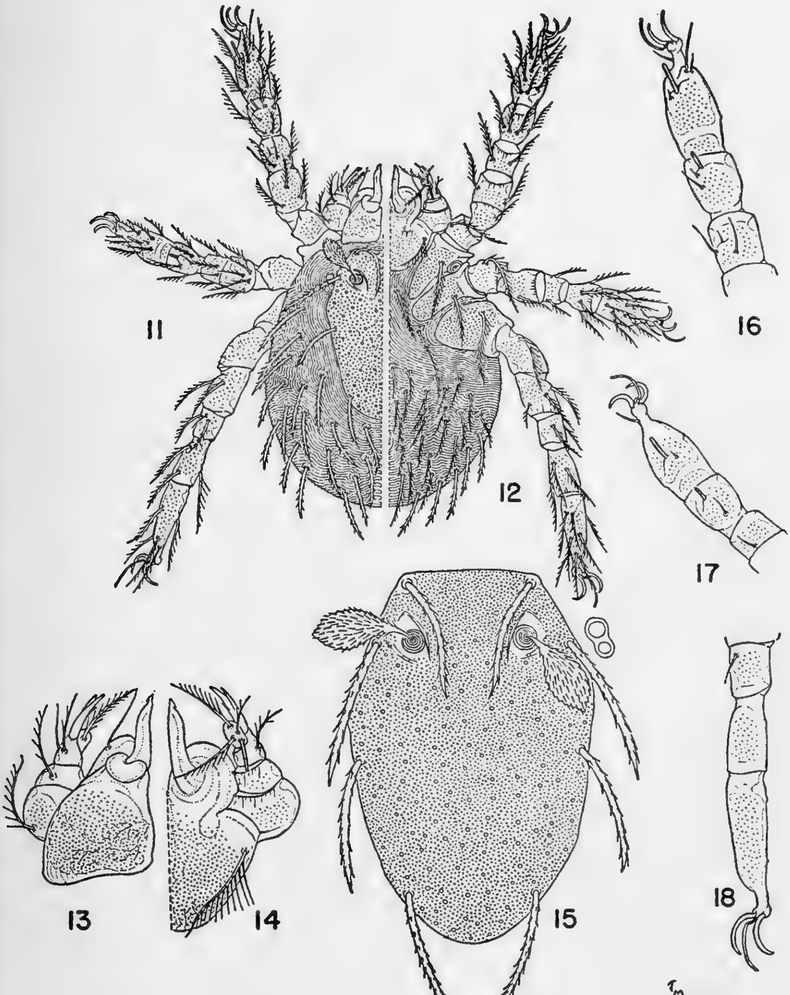
Diagnosis of larva.—Agrees with *G.* (*G.*) *exilis,* new species, in that there are four usurped marginal setae on the scutum; separable in that the *AL* setae are much shorter, approximately 45 microns, not 68, and much less bushy; the punctations on the scutum are of two sizes, not all subequal; the *PL* setae are much closer to *AL* than to *PPL-1,* instead of being midway; the palpal formula *B/B/bNB* instead of all being plumed.

Description of larva.—*Body:* Subovate, about 305 x 188 microns in partially engorged holotype. Eyes 2+2; anterior eye the larger. *Gnathosoma:* Chelicerae about four and a half to five times as long as broad at base; with a distinct tricuspid cap. Palpal setal formula *B/B/bNB;* the femoral and genual setae thinly subpectinate. Palpal claw 3-pronged. *Scutum:* Essentially as *G. exilis* regarding shape; 132 x 90 microns. Micropunctations densely and uniformly scattered, but with additional, much less numerous, coarser punctae about 1 to 2 microns in size, especially noticeable toward rear of scutum. Scutal setae rather bushy, but pinnae short. *AL* setae about two-thirds length of *PL.* Sensillae bases inserted almost at level of *PLs.* The mean distance in microns between the first (anteriormost) pair of usurped setae (*PPL-1*), is 80 (*PPW-1*), with a range ±8. Mean distance between second pair of usurped setae (*PPL-2*) is 49 (*PPW-2*), ±5. Distance from first pair of usurped setae to posterior margin of scutum is 68 (*PPP-1*), ±7. Distance from *PPL-2* to

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype, U.S.A.T.C. No. 972-27	43	71	43	23	109	28	42	60	48	71/59=1.20	0.54	3.09	71/70=1.01
Paratypes (8): Mean	46	76	45	25	116	27	44	66	50	1.24	0.58	3.0	1.09
Range + or −	3	5	3	2	8	2	3	5	4	0.05	0.08	0.1	0.08

posterior margin of scutum is 17 (*PPP-2*), ±3. *Dorsal setae:* As scutal setae, but pinnae usually more evident; about 34 to 36 in number (excluding setae usurped by scutum) often arranged: 2.2(2).2.8(2).8.6.4.2 (the numbers in parentheses referring to false scutals or



FIGS. 11-18.—*Gahrliepia* (*Gahrliepia*) *fimbriata*, new species.

usurped setae). With about 54 to 56 ventral setae, of which approximately 24 are postanals. True ventrals thin, about 23 to 28 microns in length, subpectinate. *Legs:* As in *G. exilis,* including sensory setae. Coxa III in ratio of 67 (length): 46 = 1.46.

Type material.—Holotype and 24 paratypes (U.S.A.T.C. No. 972) ex *Rattus flavipectus yunnanensis* (Anderson), China-Burma Border, Stilwell Road, April 30, 1945 (D. D. Millspaugh, for U. S. A. Typhus Commission). Holotype (U.S.N.M. No. 2155) deposited in U. S. National Museum. Paratypes distributed as for *G. exilis,* new species.

Comment.—The larger punctations or excrescences on the scutum suggest the modifications of the "ornate" species of *Gahrliepia* and indicate that *G. fimbriata* is an intermediate type in this regard.

GAHRLIEPIA (GAHRLIEPIA) DARITA, new species

Figures 19-26

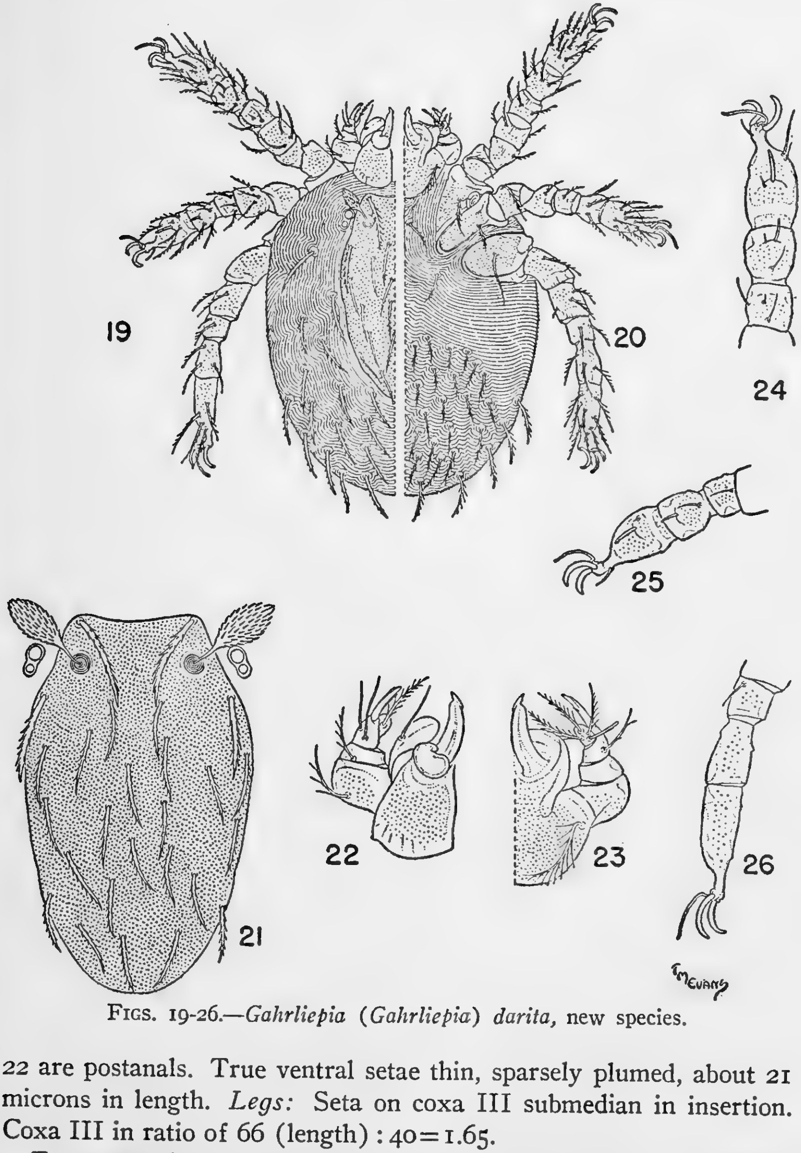
Diagnosis of larva.—Near *G. fletcheri* Gater, 1932, but separable in that the punctations are of uniform size instead of two types (cf. fig. 161, *G. fletcheri*); and in that there are 17 to 22 dorsal setae usurped by the scutum, instead of merely 10 to 17 (usually 11 or 12, rarely more than 14) such usurped setae; with 1 to 3 (usually 2) of these captured setae in a line with *PLs,* instead of being displaced caudad for a distance equal to, or greater than, length of those setae; with antesensillary ridges weak or inapparent, instead of being conspicuous.

Description of larva.—*Body:* Ovate, about 366 x 260 microns in rather engorged holotype. *Gnathosoma:* as in *G. exilis,* new species, but palpal formula *B/B/NNb*. *Scutum:* Long, broadly and evenly tongue-shaped, 152 x 94 microns in holotype. Anterior margin slightly concave; lateral margins somewhat constricted behind level of *SB* and at apical third or fourth, otherwise convex; caudally broadly rounded. Punctations uniform in size, each about one-tenth size of setal base; evenly distributed over surface. *AL* setae fairly stout, plumose; extending to about base of *PL*. Posterolateral setae similar in size and shape. Usurped setae somewhat smaller and thinner than true scutals; pinnae less developed; 17 to 22 in number, most of these nonmarginal. Ridges anterior to sensillary bases usually weakly developed, inapparent. Sensillary bases inserted midway between *AL* and *PL*. *Body setae:* Dorsal setae similar to true scutal setae but

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype, U.S.A.T.C. No. 3219-1	42	72	43	20	132	35	38	38	33	72/55=1.31	0.49	3.6	72/50=1.44
Paratypes (8):													
Mean	44	78	48	21	144	37	38	38	34	1.35	0.47	3.7	1.42
Range + or −	6	10	5	2	17	4	3	3	3	0.08	0.08	0.10	0.13

somewhat bushier than usurped setae; about 32 in number, excluding the 17 to 22 usurped setae, the rows commencing 2.4(6).4(4), the rest irregular. Ventral setae about 48 in number, of which perhaps



FIGS. 19-26.—*Gahrliepia* (*Gahrliepia*) *darita*, new species.

22 are postanals. True ventral setae thin, sparsely plumed, about 21 microns in length. *Legs:* Seta on coxa III submedian in insertion. Coxa III in ratio of 66 (length) : 40 = 1.65.

Type material.—Holotype (U.S.A.T.C. No. 3219-1) ex *Rattus rattus sladeni*, North Burma, 6 miles north of Myitkyina, October 12,

1945. Thirty-eight paratypes as follows: 1 with same data as holotype; 1, ibid., but June 14; 1, ibid., but July 10; 2, ibid., but September 11; 5, ibid., but ex *Tupaia belangeri versurae,* 20 miles west of Myitkyina on Mogaung Road, 2 of these February 16, 1 March 9, and 2 April 23; 2, ibid., but ex *Rattus* sp., on Mogaung Road, loc. cit., January 25; 3, ibid., but ex *Rattus rattus sladeni,* on Mogaung Road, loc. cit., May 22; 17, ibid., but ex *Rattus rattus sladeni,* 15 miles west of Myitkyina, October 25 and 28; 1 ex *Rattus fulvescens fulvescens,* North Burma, Shingbwiyang, April 6; 1 ex *Suncus caerulaeus fulvocinereus,* Shingbwiyang, January 10; 1 ex *Suncus,* 21 miles north of Ledo, Stilwell Road, Assam, October 25; 2 ex *Suncus,* Myitkyina, east side of Irrawaddy River, January 18; 1 ex *Crocidura,* Myitkyina, January 17. All collected by R. Traub, H. S. Fuller, D. D. Millspaugh, or Roy Melvin for the U. S. A. Typhus Commission. Holotype (U.S.N.M. No. 2156) deposited in U. S. National Museum. Paratypes distributed as for *G. exilis.*

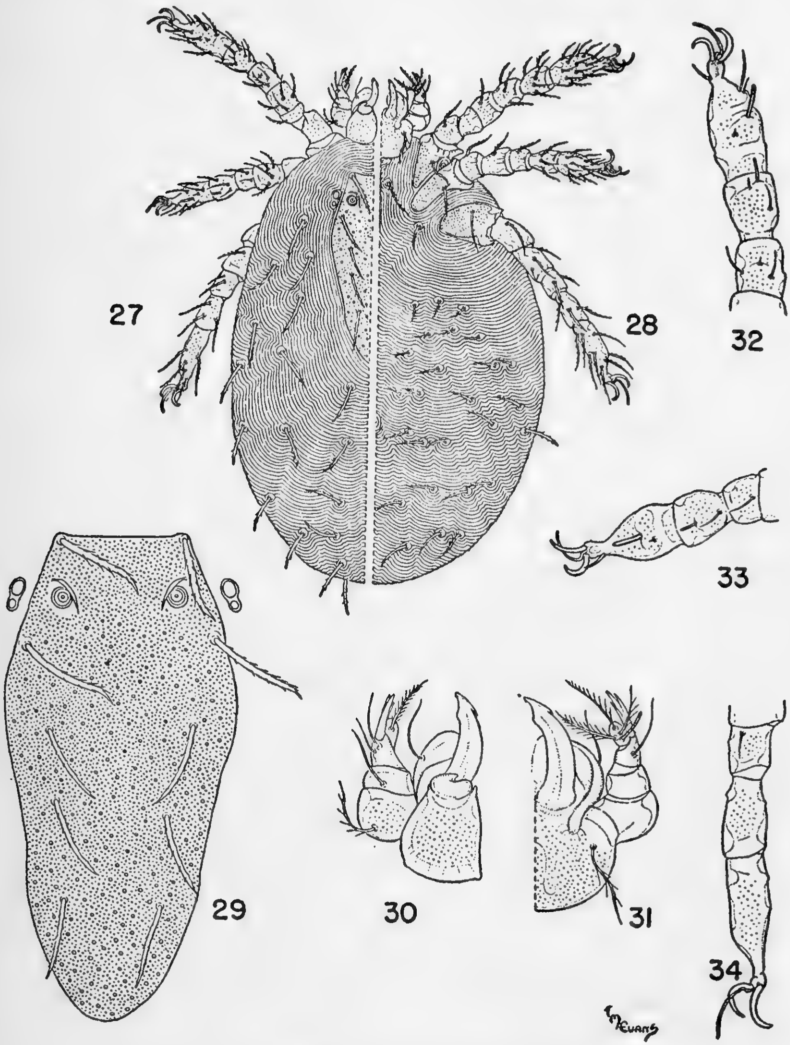
GAHRLIEPIA (GAHRLIEPIA) NETERELLA, new species

Figures 27-34

Diagnosis of larva.—Near *Gahrliepia* (*Gahrliepia*) *cetrata* Gater, 1932, regarding the low number of scutal setae and the absence of plumed setae on the palpal tibia, but distinctive in that there are 6 usurped dorsal setae on the scutum, not 4 (fig. 169). Further separable by virtue of the scutum being relatively narrower (ratio $PW:SD=0.35$ to 0.40, not 0.42 to 0.46). The only other known *Gahrliepia* with 6 usurped setae are *G. crocidura* (Radford, 1946), *G. lancearia* (Radford, 1946), and *G. romeri* Womersley, 1952. The first two are considered synonyms, as is pointed out later in this paper. *G. neterella* and *G. crocidura* are readily separable in that the scutum of *G. neterella* is obviously relatively much narrower and longer, i.e., *PW* 74 not 85; *SD* 191, not 146, but *ASB* nevertheless virtually the same. The longer and narrower scutum also serves to separate *G. neterella,* new species, from *G. romeri,* in which *PW* is approximately 86, but *PSB* 157. In *G. neterella,* new species, the palpal femoral seta is branched, whereas it is nude in *G. romeri.*

Description of larva.—*Body:* Subovate, about 454 x 273 microns when somewhat engorged. Eyes double, anteriormost the largest. *Gnathosoma:* Chelicerae about three and a half to four times as long as broad at base; with distinct apical tricuspid cap. Palpal setal formula *B/N/NNN*. Palpal claw 3-pronged. *Scutum:* Long and fairly narrow, about 200 x 96 microns at maxima in rather large holotype. Anterior margin quite straight. Lateral margins with rounded shoul-

ders at anterior third, slightly concave below shoulders but becoming slightly convex at posterior third, only to narrow rapidly toward evenly convex caudal margin. Uniformly micropunctate, but in addi-



FIGS. 27-34.—*Gahrliepia* (*Gahrliepia*) *neterella*, new species.

tion with coarser, much less numerous punctae. *AL* setae at anterolateral angles of scutum; fairly stout and at times somewhat bushy, but pinnae usually appressed, often inapparent. *PL* setae similar, but slightly longer. Usurped scutal setae submedial in position; first

pair slightly below lateral "shoulders" of scutum; second pair at level of scutal midline; third pair at posterior third. All usurped setae with adpressed setae; somewhat shorter and thinner than true scutals. Sensillary bases inserted at level midway between *AL* and *PL*, with a conspicuous ridge anterior to each sensillary base. Sensillae absent in specimens extant. *Body setae:* Dorsal setae similar to scutal setae;

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype, C.O.M.R.U. No. 30006	47	74	45	26	174	43	35	42	36	74/59=1.25	0.37	2.8	74/60=1.23
Paratypes (11): Mean	46	73	43	25	166	41	35	39	35	1.28	0.38	2.9	1.25
Range + or −	3	3	3	2	12	3	3	3	3	0.07	0.05	0.1	0.06

about 32 to 34 in number (excluding those captured by scutum); arranged 2.4(2).4(2).4(2).6, the rest irregular. With about 50 to 54 ventral setae, of which 20 are postanals but which nevertheless are shorter and distinctly thinner than dorsals. True ventrals about 21 microns, thin, pinnae virtually inapparent. *Legs:* Seta on coxa III somewhat submarginal. Coxa III in ratio of 65 (length) : 46 = 1.41. Legs otherwise as in *G. exilis,* new species.

Type material.—Holotype (C.O.M.R.U. No. 30006) ex *Rattus sabanus* (Thomas), Malaya, Selangor, Ulu Langat, August 26, 1952 (J. R. Audy and J. L. Harrison, for the Colonial Office Medical Research Unit). Thirteen paratypes as follows: 2 with same data as holotype; 2 ex *Rattus bowersi* (Anderson), loc. cit., August 2 and October 14, 1952 (J. R. Audy); 4 ex *Rattus sabanus* (Thomas), loc. cit., August 26 and 31, 1951 (R. Traub, for the U. S. Army Medical Research Unit); 5 ex *Rattus mülleri* (Jentinck), loc. cit. (R. Traub), but July 2, 1951. Holotype (U.S.N.M. No. 2157) in U. S. National Museum. Paratypes distributed among collections of U. S. National Museum, Colonial Office Medical Research Unit, Kuala Lumpur, and that of senior author.

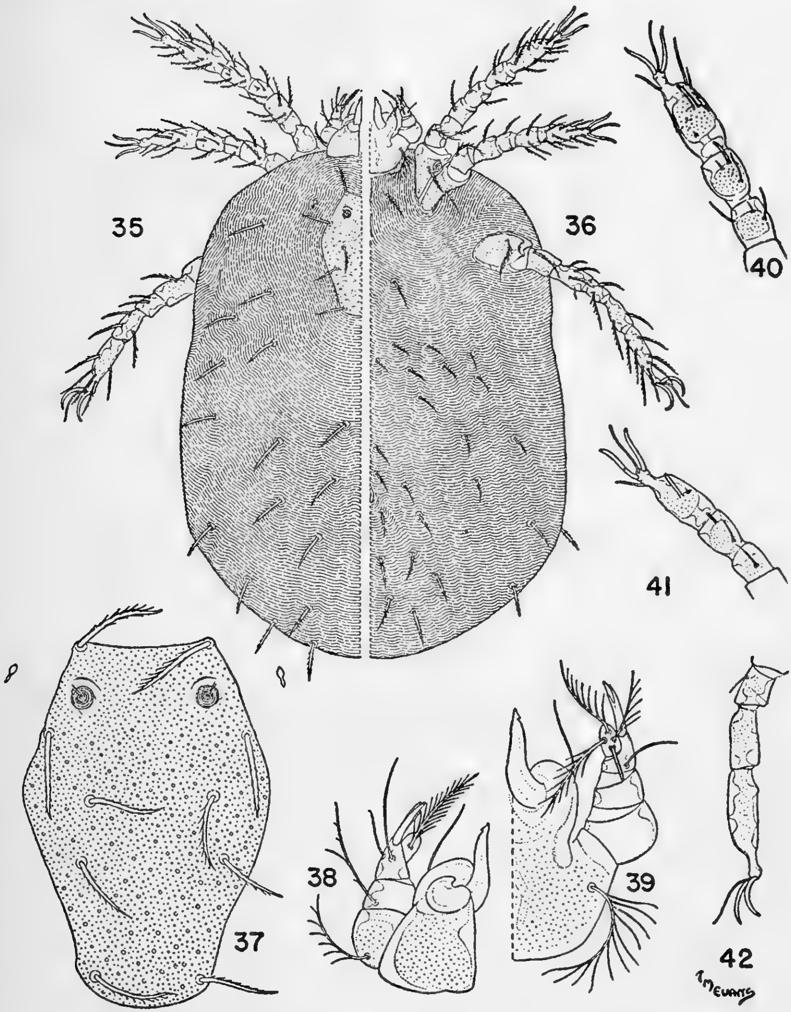
Comment.—Since this chigger was collected from three species of rats that are denizens of true primary forest, and because it was never taken on any of the thousands of *Rattus rattus* ssp. inhabiting scrub terrain, it is highly probable that *G. neterella* is a characteristic jungle-inhabiting form.

GAHRLIEPIA (GAHRLIEPIA) TENELLA, new species

Figures 35-42

Diagnosis of larva.—Distinguished from all other nonscrobiculate species in the subgenus which possess normal *ALs* and *PLs* (i.e.,

PLs not moved forward so as to be contiguous with *ALs*) by the following combination of characters: (1) scutum subcaudally constricted and posterior margin subtruncate (fig. 37), and (2) with 6



FIGS. 35-42.—*Gahrliepia* (*Gahrliepia*) *tenella*, new species.

usurped setae. Agreeing with *G.* (*G.*) *neterella* regarding number of usurped setae, but instantly separable by shape of scutum (cf. fig. 29) and by *PSB* being 123, not 166.

Description of larva.—Body: Subovate, but only specimen extant ruptured on remounting. Eyes double, but quite reduced. *Gna-*

thosoma: Chelicerae about four and a half times as long as broad near base. Palpal setal formula *B/f/NNN.* Palpal claw 3-pronged. *Scutum:* Somewhat less than 1½ times as long as broad (146 x 102 microns); broadest at about level of anterior third; slightly constricted between levels of *PPL-2* and *PPL-3.* Caudal margin relatively subtruncate. *AL* setae at anterolateral angles of scutum; somewhat plumose; in vertical line with sensillae bases. *PLs* marginal; resembling *ALs* but slightly longer than *ALs.* *SB* inserted at level midway between *ALs* and *PLs.* Sensillae absent in specimen. With 6 usurped setae arranged in 3 rows of 2 each. With 2 kinds of punctae—one almost the size of the setal bases and uniformly distributed posterior to *SB;* the second type, the ordinary micropunctae, scattered over the scutum. *Body setae:* Dorsal setae similar to scutal setae; about

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype, U.S.A.T.C. No. 971-1	51	79	51	23	123	40	33	36	30/37	79/60=1.31	0.54	3.4	79/63=1.25

32 in number arranged 2.4.4.6.6.4.4.2 (excluding usurped setae). With about 48 ventral setae, of which 18 are postanals. True ventrals short, about 20 to 23 microns; sparsely plumed. *Legs:* Coxa III length to breadth in ratio of 63:40 microns (=1.6). With two pairs of typical sternal setae. Sensory setae as in *G. exilis.*

Type material.—Holotype ex *Rattus flavipectus yunnanensis* (Anderson), China-Burma border on Stilwell Road, April 30, 1945 (U. S. A. Typhus Commission). No other specimen known. Deposited in U. S. National Museum (U.S.N.M. No. 2158).

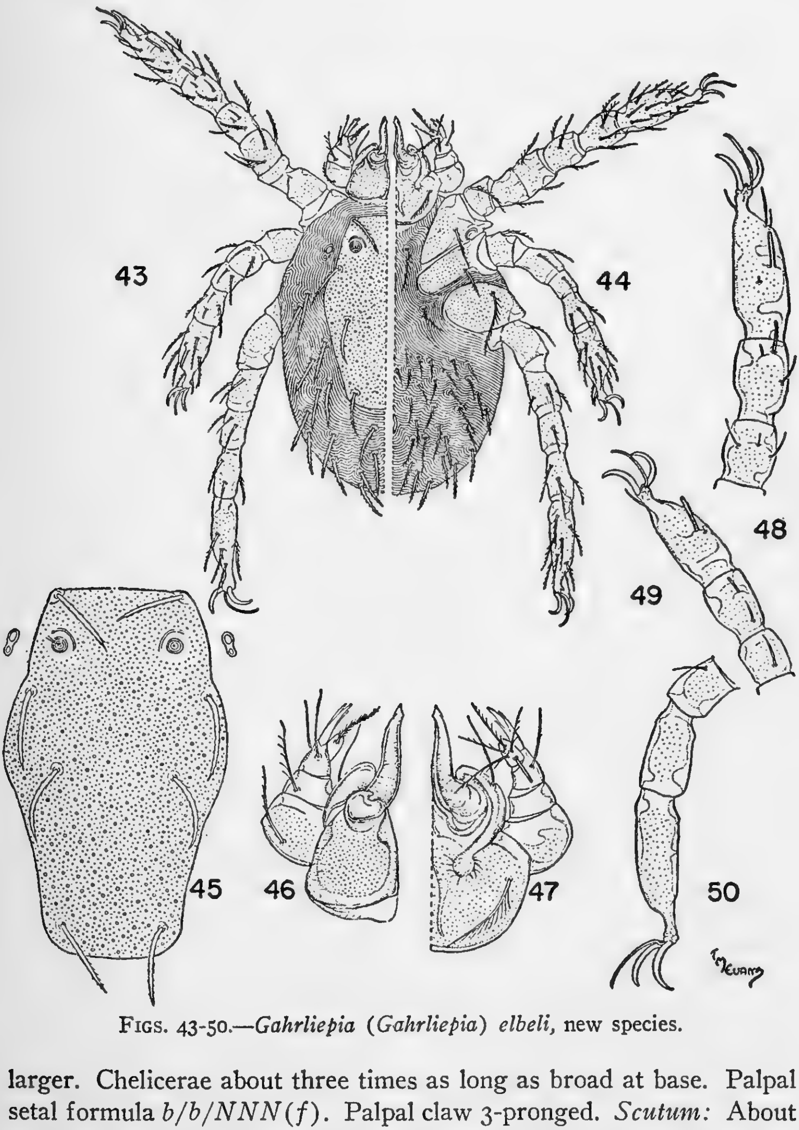
GAHRLIEPIA (GAHRLIEPIA) ELBELI, new species

Figures 43-50

Diagnosis of larva.—Near *G. tenella,* new species, especially as regards subtruncate posterior margin of scutum but readily separable in that (1) the scutum (fig. 45) bears only 4 usurped setae, not 6 (fig. 37); (2) posterior third of scutum with lateral margins subparallel to near apex instead of sloping to near apex. Separable from other nonscrobiculate *Gahrliepia* with 4 usurped setae in that the posterior margin of the scutum is subtruncate. Near *G. cetrata* Gater, 1932, but further distinguishable in that *PW* is less than 75 microns, instead of in the vicinity of 90, and in that *PPL-2* is immediately in front of the posterior margin of the scutum (less than 14 microns) instead of being midway between *PPL-1* and the posterior margin. Re-

sembling *G. exilis,* new species, but with dorsal and scutal setae far less bushy and much shorter than that species, e.g., *AL* 28 microns, not 68.

Description of larva.—Body: Subovate, about 245 x 142 microns in virtually unengorged holotype. Eyes double; anterior ones the



FIGS. 43-50.—*Gahrliepia (Gahrliepia) elbeli,* new species.

larger. Chelicerae about three times as long as broad at base. Palpal setal formula *b/b/NNN(f)*. Palpal claw 3-pronged. *Scutum:* About 85 x 127 microns; broadest at about anterior third. Anterior margin fairly straight. Lateral margins with anterior fourth declivate; con-

vex between *PL* and *PLL-1* and then becoming sinuate, but posterior portion subparallel. Posterior margin definitely squarish. With two kinds of punctae, the larger pits somewhat smaller than the setal bases and scattered over the caudal three-fourths of scutum; the micropunctae uniformly scattered. *AL* setae relatively thin, extending to about level of *SB*. *PL* setae similar in structure but slightly longer; extending to level of first usurped setae. With a distinct ridge anterior to sensillary bases, which are midway between levels of *ALs* and *PLs*. (Sensillae absent or distorted in specimens extant.) *PPL-1* median, in vertical line with *SB* and near imaginary midline of scutum. *PPL-2* almost in line with *PPL-1*. Both pairs of usurped setae resembling *PLs*. *PPW-1* is 49 (±4); *PPW-2*, 43 (±5); *PPP-1*, 65 (±5);

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype, No. B-17719-5	46	66	43	20	107	38	26	30	28	66/49=1.35	0.53	3.3	68/52=1.27
Paratypes (3):													
Mean	47	70	45	20	114	38	27	32	30	1.36	0.52	3.5	1.32
Range + or —..........	3	4	4	3	8	2	3	3	3	0.08	0.07	0.4	0.08

PPP-2, 12 (±2). *Body setae:* Dorsal setae similar to *ALs;* about 28 (24 to 32) in number (excluding usurped setae), usually arranged 4.4.8.6, the rest irregular. With about 46 to 60 ventral setae, of which about 15 to 20 are postanals. True ventrals thin, about 19 microns in length, with fine pinnae. *Legs:* Coxae 1-setose. Coxa III length to breadth, 54:47 microns (ratio=1.15). Sternal setae arranged 2-2. Sensory setae as *G. exilis,* new species.

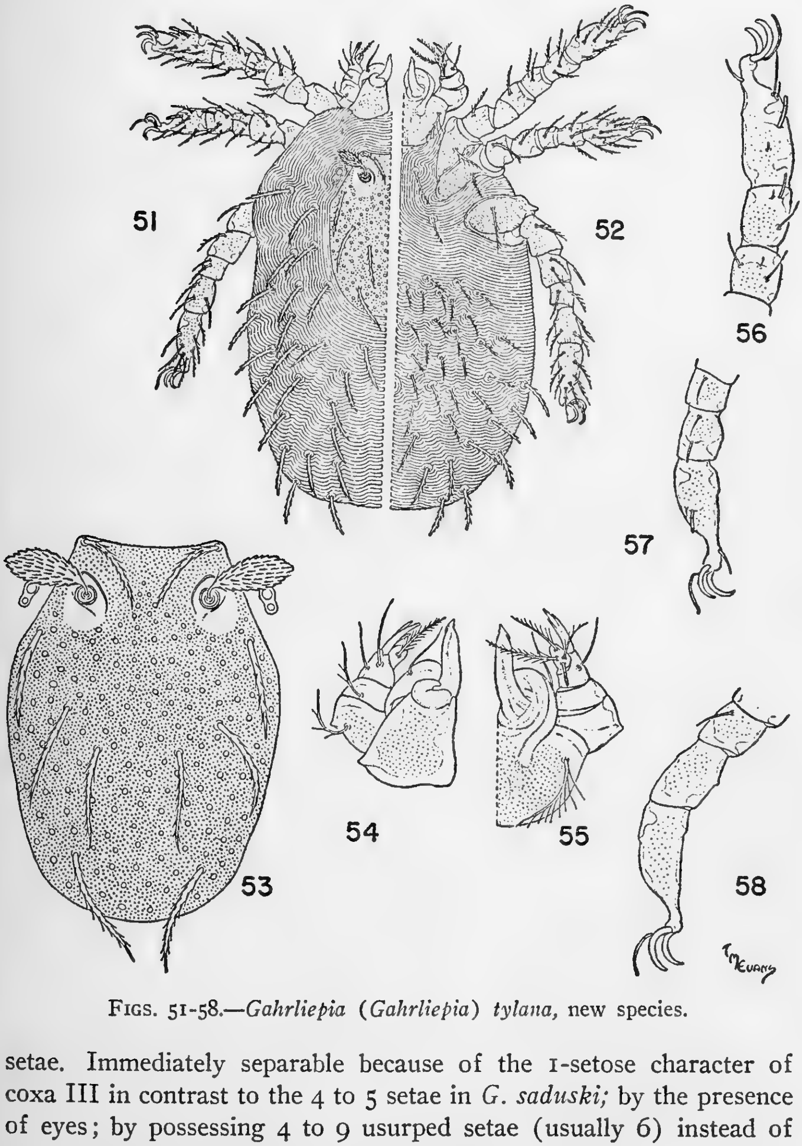
Type material.—Holotype (No. B-17719-5) and three paratypes ex the ground squirrel, *Menetes berdmorei* Blyth, 1849, Thailand, Nan, Pang Nam Un, January 21, 1953 (H. G. Deignan, ornithologist, U. S. National Museum, and Robert E. Elbel, U. S. Special Technical and Economic Mission to Thailand). Holotype (U.S.N.M. No. 2159) deposited in collections of U. S. National Museum. Paratypes in collections of senior author and Colonial Office Medical Research Unit at Kuala Lumpur.

Comment.—The species is named for Robert E. Elbel of the U. S. Special Technical and Economic Mission to Thailand, who, while working with the Thai Ministry of Public Health Division of Communicable Diseases on the control of arthropod-born diseases of Thailand, also contributed much to our knowledge of potential vectors of disease in that country.

GAHRLIEPIA (GAHRLIEPIA) TYLANA, new species

Figures 51-58

Diagnosis of larva.—Near *G.* (*G.*) *saduski* Womersley, 1952, in the shape of the scutum and the rather bushy character of the dorsal



FIGS. 51-58.—*Gahrliepia* (*Gahrliepia*) *tylana*, new species.

setae. Immediately separable because of the 1-setose character of coxa III in contrast to the 4 to 5 setae in *G. saduski;* by the presence of eyes; by possessing 4 to 9 usurped setae (usually 6) instead of 2 to 5, and by possessing small scutal pits in addition to punctae, in-

stead of merely punctae. Agreeing with *G.* (*G.*) *rutila* Gater, 1932, and *G.* (*G.*) *romeri* Womersley, 1952 (new combination) in the approximate number of dorsal setae captured by the scutum. Distinguishable from *G. romeri* as follows: Scutum with scattered small pits in addition to punctae, instead of being merely uniformly punctate. Palpal claw 3-pronged, not 2-pronged. Ratio of *SD:PW* is 1.8, not 2.15. *PSB* less than 131 instead of 157. Separable from *G. rutila* for the following reasons: Scutum with small pits as well as punctae, instead of merely punctae. *PSB* more than 116 instead of approximately 100. Ratio *SD:PW* = 1.8, not 1.6. *SB* more than 45 instead of approximately 41. Some of the palpal setae branched instead of being nude. With about 40 dorsal setae, not approximately 26. The shape of the scutum immediately separates this species from *G. tenella*, new species, which also has 6 usurped setae (fig. 37).

Description of larva.—Body: Subovate, about 424 x 288 microns when fairly engorged. Eyes double; on ocular plate; anterior eye the larger. *Gnathosoma:* Chelicerae about four to four and a half times as long as broad at base; with typical distal tricuspid cap but apex more deeply sclerotized, acuminate. Palpal setal formula *B/B/b(N)NN*. *Scutum:* Long (as typical for genus) but relatively quite broad; less than one and a half times as long as broad (150 x 114 microns in holotype). Anterior margin slightly concave. Lateral margins oblique to an "angle" caudal to *PLs* and then shallowly convex. Caudal margin broadly and evenly rounded. With small pits the size of setal bases scattered over surface of scutum, interspersed among micropunctations. *AL* setae stout, bushy. *PL* setae resembling *ALs* but somewhat longer. Number of dorsal setae usurped by scutum varying from 4 to 9 but generally with 6. Of the typical 3 pairs, first pair (*PPL-1*) inserted somewhat anterior to midline and more medial in position; *PPL-3* at distal sixth. Usurped setae resembling *PLs*. With a distinct ridge anterior to sensillary bases; the general area devoid of pits or punctae. Bases of sensillae about as close to imaginary line connecting *ALs* as to level of *PLs*, but each base in vertical line with each *AL*. Sensillae clavate; about three times as long as broad (35 x 11 microns), excluding petiole. *PPW-1* is 72 (±9); *PPW-2*, 47 (±6); *PPP-1*, 80 (±9); *PPP-2*, 63 (±8). *Body setae:*

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PBS*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype, C.O.M.R.U. No. 32133	51	85	49	22	128	39	32	39	39	85/53=1.60	0.56	4.0	85/53=1.60
Paratypes (8): Mean	49	80	49	22	123	38	33	39	39	1.52	0.52	3.6	1.61
Range + or −	3	6	4	2	7	2	3	4	5	0.08	0.06	0.5	0.08

Dorsal setae resembling scutal setae; about 42 to 46 in number, excluding those on scutum; the rows erratic but at times arranged 4.4(4).6(2).8.8, the rest irregular. Ventral setae about 62 to 66 in number of which about 20 are postanals. Caudal and lateral setae approximating dorsals in length and breadth. True ventrals about 22 microns in length; thin, pinnae appressed to stem. *Legs:* Seta on coxa III medial. Coxa III, ratio of length to breadth 64:42=1.55. Sternal setae 2-2; in usual sites; about 27 microns in length. Sensory setae and dorsal claws as in *G. exilis,* new species.

Type material.—Holotype (C.O.M.R.U. No. 32133) ex *Bandicota* sp. (B. *bengalensis?*), Thailand, Kanchanaburi, Kanchanaburi (district) (R. E. Elbel, for U. S. Special Technical and Economic Mission to Thailand, and plague control workers of the Thai Division of Communicable Diseases), June 9, 1952. Fourteen paratypes with same data. One paratype, ibid., but *Menetes berdmorei* (Blythe), Municipality, 1 kilo. west (R. E. Elbel), June 9, 1952. Five paratypes, ibid., but collected at Rat Buri, Ban Pong, June 14 and 17. Holotype (U.S.N.M. No. 2160) deposited in U. S. National Museum. Paratypes distributed as for *G. exilis,* new species.

GAHRLIEPIA (GAHRLIEPIA) GEMINA, new species

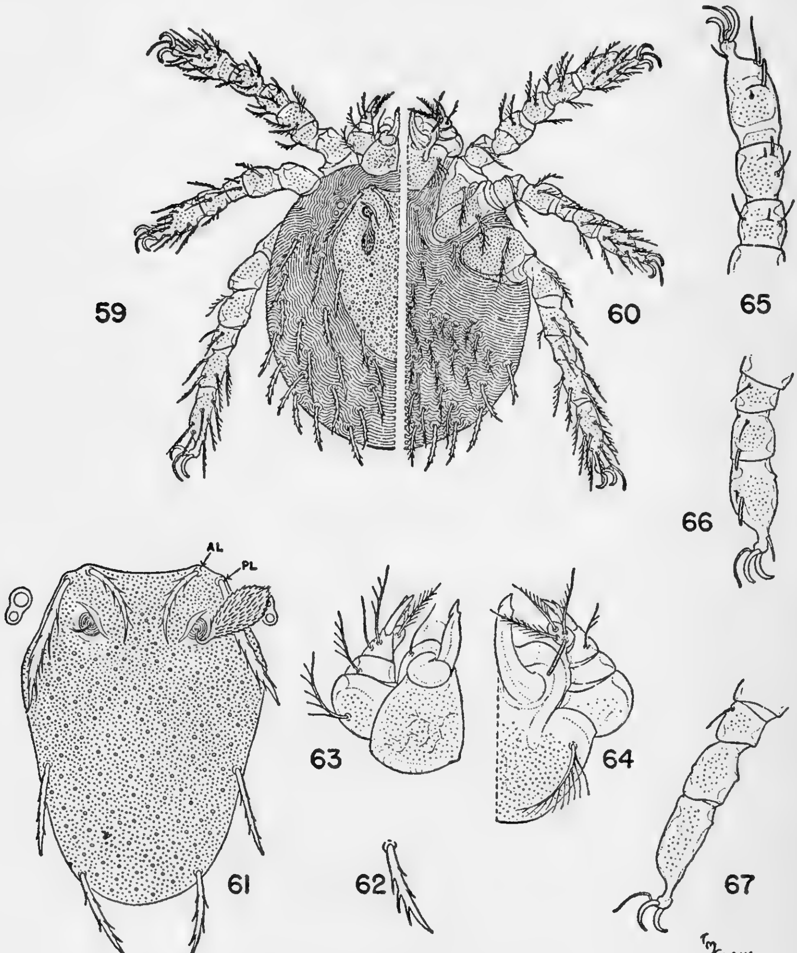
Figures 59-67

Diagnosis of larva.—Along with *G. hirsuta* (Radford, 1946), unique in that the *PL* setae have moved anterior to adjoin the *ALs.*[9] Immediately separable from *G. hirsuta* in that the posterior margin of the scutum is broadly ovate instead of acutely angled; with but 4 usurped setae on scutum (i.e., a total of 8 scutal setae), all marginal, instead of 8 usurped setae, 4 of which are medial.

Description of larva.—*Body:* Ovate, about 271 x 200 microns when partially engorged. Eyes double, anterior one the larger. *Gnathosoma:* Chelicerae relatively broad, about three and a half times as long as broad at base. Palpal setal formula *B/B/BNb,* the *B* setae subpectinate. Palpal claw apparently 3-pronged, but appearing 2-pronged. *Scutum:* Relatively quite broad, about four-fifths as broad as long at maxima (84 x 113 microns). Anterior margin concave between *ALs.* The rounded shoulders of lateral margins occuring at anterior two-fifths. Lateral margins posterior to shoulders gently but irregularly sinuate. Caudal margin somewhat convex. With two kinds of punctae, i.e., with coarser punctae about one-half to one-

[9] Two new species subsequently described herein also possess *PLs* adjacent to *ALs.*

fourth size of setal bases scattered among the more numerous micropunctations. *AL* setae (fig. 61, *AL*) bushy, thick, displaced from anterolateral angles by the nearly contiguous *PLs.* Posterolateral



FIGS. 59-67.—*Gahrliepia* (*Gahrliepia*) *gemina*, new species.

setae (fig. 61, *PL*) longer than *ALs,* in ratio of 10:7; thick and bushy; bases almost in line with those of *AL.* With two pairs of dorsal setae usurped by scutum; both pairs marginal, resembling *ALs;* of these usurped setae, one pair inserted well below shoulders and somewhat below midline; second pair near posterior margin. With a pronounced oblique ridge anterior to sensillae bases. Sensillae inserted

at level of anterior sixth of scutum. Sensillae clavate; with a long petiole; three and a half times as long as broad. *PPW-1* is 70 (± 6); *PPW-2*, 40 (± 6); *PPP-1*, 54 (± 7); *PPP-2*, 15 (± 4). *Body setae:*

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype, U.S.A.T.C. No. 1035-6	36	52	41	21	92	10	35	50	36	52/58=0.9	0.46	2.5	52/53=0.98
Paratypes (16):													
Mean	37	54	42	21	97	10	34	49	36	0.96	0.45	2.5	0.94
Range + or —	4	6	5	3	5	2	4	4	3	0.07	0.06	0.5	0.06

Dorsal setae (fig. 62) usually thicker than usurped scutal setae; with but 3 to 5 fairly stout barbs, these subpectinate in appearance; about 32 to 36 in number (excluding usurped setae), arranged 4.4(2).6 (2).8, the rest irregular. Ventral setae about 50 in number, of which about 22 to 26 are postanals rather resembling dorsal setae. True ventrals thin, short, about 15 to 18 microns, with fine pinnae. *Legs:* Coxae 1-setose. Coxa III relatively broad, ratio of length to breadth about 1.17; with seta almost anteromarginal. First pair of sternal setae long, extending almost to bases of posterior sternals. With 4 sternal setae between coxae III, the extra pair probably due to forward displacement of two true ventral setae. Sensory setae as in *G. exilis*, new species.

Type material.—Holotype (U.S.A.T.C. No. 1035-6) ex *Rattus rattus sladeni* (Anderson), North Burma, 20 miles northwest of Myitkyina on Mogaung Road (in the forest edge), May 22, 1945 (U. S. A. Typhus Commission). Thirty-three paratypes as follows (all collected U.S.A.T.C. unless otherwise specified): 17 with same data as holotype; 8, ibid., but ex *Rattus fulvescens fulvescens* (Gray), April 23, 1945; 3, ibid., but ex *Rattus* sp., January 24; 3 ex *Tupaia* at Shadazup, September 2, 1944 (H. S. Fuller); 1 ex *Rattus r. sladeni,* at Shingbwiyang, May 8; 1 ex *Crocidura vorax* Allen at Shingbwiyang, January 10. Holotype (U.S.N.M. No. 2161) and three paratypes deposited in U. S. National Museum. Paratypes distributed as for *G. exilis,* new species.

Comment.—*G. gemina* was collected on 16 occasions in North Burma. In all instances it was taken in primary jungle or heavy forest but only during the dry season. When collected, this chigger constituted between 2 and 4 percent of all the trombiculids examined from the particular host, but the percentage was usually less than 10 percent.

The specific name was suggested by the approximation of the *PL* and *AL* setae. What we have here called the posterolateral setae

(*PLs*) are longer and stouter than the *ALs,* as is usually the case in typical *Gahrliepia.* Both pairs of setae are better developed than the other setae on the scutum. This indicates that our ideas of homology are correct, and that there are not two pairs of *ALs.*

GAHRLIEPIA (GAHRLIEPIA) DUPLISETA, new species

Figures 68-75

Diagnosis of larva.—Agrees with *G. gemina,* new species, in that the *PL* setae adjoin the *ALs* and the scutum is caudally rounded, not angled. Immediately separable in that the usurped scutal setae are submedian, not marginal; the *PL* setae are nearly twice the length of the *ALs,* instead of merely being in the ratio of 10:7; *PSB* proportionately far greater (*PSB,* 122 microns; *PSB/SB* ratio 3:1, not approximately 2:1), so that scutum is merely three-fifths as broad as long, not three-fourths.

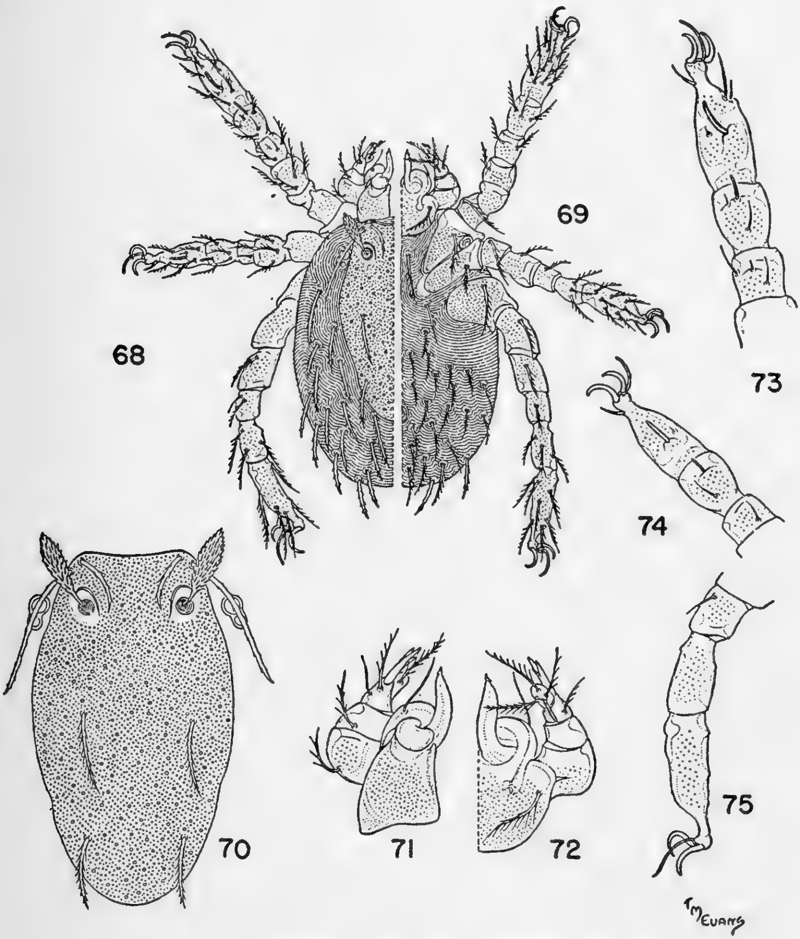
Description of larva.—*Body:* Subovate, about 236 x 134 microns in partially engorged holotype. Eyes double, anterior one the larger. *Gnathosoma:* Chelicerae about four and a half times as long as broad at base. Palpal setal formula *B/B/BNB.* Palpal claw 3-pronged. *Scutum:* Relatively long, about three-fifths as broad as long at maxima (82 x 143 microns). Anterior margin slightly concave. Lateral margins fairly evenly convex, lacking distinct shoulders, slightly sinuate below level of sensillae bases and at about level of apical three-fourths. Caudal margin convex. With two kinds of punctae as in *G. gemina,* new species. *AL* setae relatively thin, somewhat plumose. *PL* setae similar in structure, but extending caudal to slightly below level of first usurped setae. Bases of *PL* almost contiguous with *AL,* the separation distance being about twice the diameter of the setal bases. The two pair of dorsal setae captured by scutum are in line with sensillary bases; thinly but distinctly barbed; anterior pair about 40 microns in length, inserted about level of midline; posterior pair 36 microns, inserted at posterior seven-eighths. With a distinct ridge anterior to sensillae bases. Sensillae inserted at level of anterior eighth of scutum. Sensillae clavate. *PPW-1* is 43; *PPW-2,* 39; *PPP-1,* 76; *PPP-2,* 26. *Body setae:* Dorsal setae similar to

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype, U.S.A.T.C. No. 3562-1	42	56	40	21	122	8	36	60	35	56/52=1.1	0.4	2.7	56/51=1.09

ALs; about 30 in number (excluding usurped setae) irregularly arranged. Ventral setae about 44 in number, of which about 26 are

postanals. True ventrals thin, fairly short, about 26 microns in length, with fine pinnae. *Legs:* Coxae 1-setose. Coxa III relatively broad, ratio of length to breadth about 1.17 with seta almost anteromarginal. Sternal setae arranged 2-2. Sensory setae as in *G. exilis,* new species.



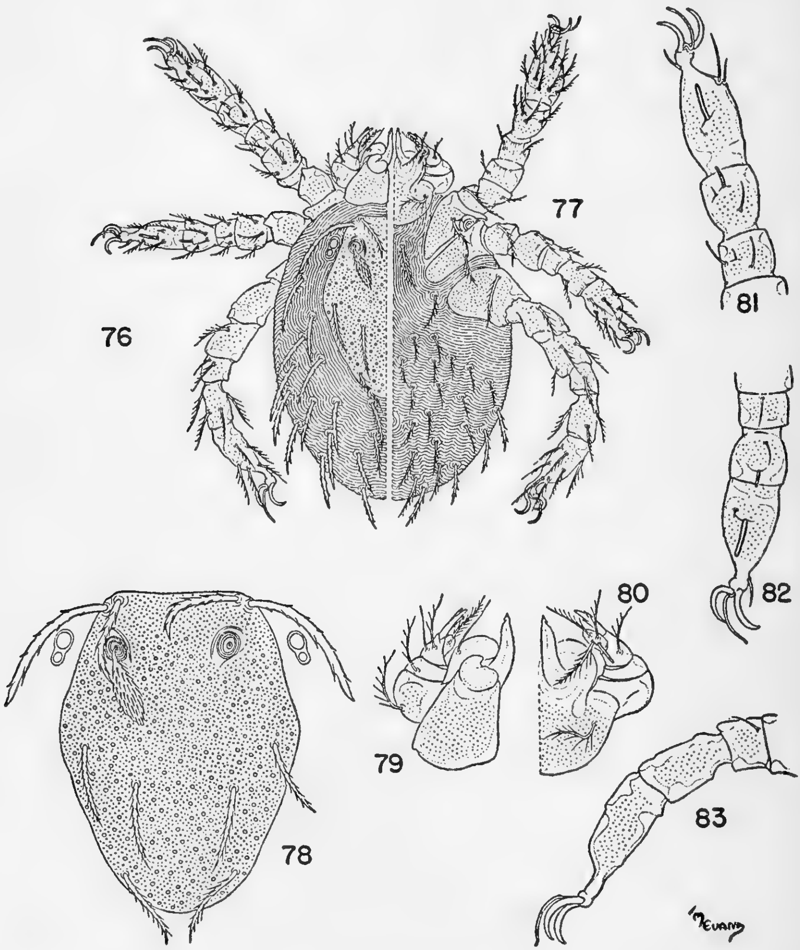
FIGS. 68-75.—*Gahrliepia* (*Gahrliepia*) *dupliseta,* new species.

Type material.—Holotype (U.S.A.T.C. No. 3562-1) ex *Suncus caerulaeus fulvocinereus* (Anderson), the white-toothed shrew, Assam, 21 miles north of Ledo on Stilwell Road (in scrub terrain), August 28, 1945 (U. S. A. Typhus Commission). Holotype (U.S.N.M. No. 2162) deposited in U. S. National Museum. A paratype from same host and locality in collection of senior author.

GAHRLIEPIA (GAHRLIEPIA) PLURISETAE, new species

Figures 76-83

Diagnosis of larva.—Similar to *G. gemina* and *G. dupliseta*, new species, in that the *PL* setae adjoin the *ALs* and in that the scutum is



Figs. 76-83.—*Gahrliepia* (*Gahrliepia*) *plurisetae*, new species.

caudally rounded, not angled. Readily separable from both by virtue of possessing an additional 2 medial setae on the scutum. Further distinguishable from *G. gemina* as follows: The lateral angles of the scutum much nearer midline instead of being at anterior fifth (cf. figs. 61 and 78); *PPL-1* virtually at level of scutal angles instead of

far posterior; *PPL-1* submarginal, not marginal; with but one pair of sternal setae between coxae III. Further separable from *G. dupliseta* in that the scutum is relatively broader, three-fourths as broad as long instead of three-fifths as broad as long, as in *G. dupliseta;* the *PPL-1* setae not submedial, but merely submarginal.

Description of larva.—Body: Subovate, about 247 x 165 microns in slightly engorged holotype. Eyes double, anteriormost somewhat the larger. *Gnathosoma:* Chelicerae about four to four and a half times as long as broad at base. Palpal setal formula *B/B/BNB,* the *B* setae subpectinate. Palpal claw 3-pronged. *Scutum:* Relatively broad, 88 x 117 microns in holotype. Anterior margin fairly straight. Lateral margins gently angled near midpoint. Caudal margin rather broadly rounded. With 2 kinds of punctae as in *G. gemina. AL* setae bushy, thick, three-fifths length of *PLs;* displaced from anterolateral angles by the nearly contiguous *PLs.* With 3 pairs of dorsal setae usurped by scutum; a submarginal pair at lateral angles of scutum; a medial pair at three-fourths level, and a caudomarginal pair. With a pronounced oblique ridge anterior to sensillae bases. Sensillae inserted at level of anterior sixth of scutum. Sensillae clavate. *PPW-1* is 64 (±7); *PPW-2,* 37 (±4); *PPP-1,* 62 (±3); *PPP-2,* 19 (±3). (For purposes of homology with *G. gemina* and

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype, U.S.A.T.C. No. 3562-2	37	52	39	20	97	9	32	51	35	52/52=1.0	0.45	2.65	52/46=1.13
Paratypes (2): Mean	40	54	42	19	103	8	34	53	36	1.0	0.45	2.8	1.09
Range + or —	2	2	4	1	6	1	4	4	4	0.05	0.04	0.15	0.05

allies, the caudomarginal usurped pair are considered here when measuring *PPW-2* and *PPP-2,* and not the submedial third pair.) *Body setae:* Dorsal setae usually slightly thicker than *PLs;* about 28 in number (excluding scutals), arranged 2.4(2).4(2), the rest irregular. Ventral setae about 40 in number, of which about 22 are postanals. These postanals much thinner than dorsals. True ventrals even thinner; short, about 15 to 18 microns, with fine pinnae. *Legs:* Coxae 1-setose. Coxa III relatively broad, ratio of length to breadth about 1.18; with seta almost anteromarginal. Sternal setae of usual type (as in *G. exilis,* new species). Sensory setae as in *G. exilis.*

Type material.—Holotype (U.S.A.T.C. No. 3562-2) ex *Suncus caerulaeus fulvocinereus* (Anderson), the white-toothed shrew, Assam, 21 miles north of Ledo on Stilwell Road (in scrub terrain), August 28, 1945 (U. S. A. Typhus Commission) (along with *G. dup-*

liseta, new species). Paratypes as follows: 1, ibid., but June 17; 1, ibid., but June 29. Holotype (U.S.N.M. No. 2163) deposited in U. S. National Museum. One paratype in U. S. National Museum, other in collection of senior author.

Comment.—The three specimens of this species were all taken in scrub terrain in Assam in the rainy season, in contrast with the many specimens of the related *G. gemina,* new species, which were collected at intervals in the jungles of North Burma in the dry season.

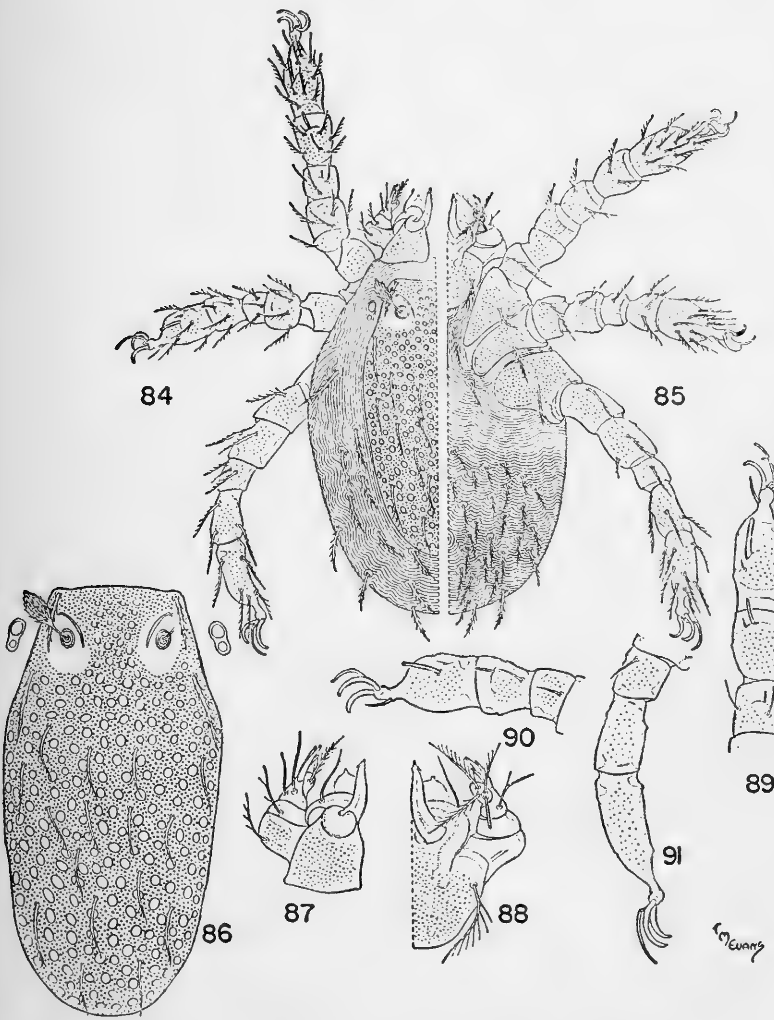
GAHRLIEPIA (GAHRLIEPIA) EVANSI, new species

Figures 84-91

Diagnosis of larva.—Unique among described Asiatic *Gahrliepia* with a scrobiculate or "ornate" scutum (*insigne* Womersley, 1952; *decora* Womersley, 1952, and *ornata* Womersley, 1952) in that there are about 17 dorsal setae usurped by the scutum, not merely 4, and most of them are medial instead of all being marginal.

Description of larva.—*Body:* Subovate, about 234 x 146 microns in slightly engorged holotype. Eyes double; anterior eye the larger; at level of sensillary bases; ocular plate adjacent to scutal margins. *Gnathosoma:* Chelicerae about four to five times as long as broad at base; with a distinct distal tricuspid cap; apex quite long, acuminate. Palpal setal formula *b/b/NNb.* Palpal claw 3-pronged; innermost prong slightly shorter than others; middle one longest. *Scutum:* Long, broadly and evenly tongue-shaped; about 155 x 81 microns at maximum (in holotype). Anterior margin essentially straight except for slight "shoulders" at insertion of *ALs.* Lateral margins fairly straight but oblique to level of a weak angle somewhat below *PLs,* thence very shallowly convex and almost subparallel most of its length. Lateral margins most heavily sclerotized between *AL* and *PL.* Posterior margin broadly rounded. Uniformly micropunctate except around *SB* and where scutum is ornamented by conspicuous subovate scrobiculi, dimples or pits two to four times the diameter of the setal bases. Scrobiculi distributed evenly over portion of scutum behind *SB* at rate of about 6 to 9 pits between each pair of usurped setae. Scrobiculi anterior to *SB* about one-third to one-half diameter of those posterior to *PL. AL* setae at anterolateral angles of scutum; thin but plumose. *PL* setae similar but slightly longer, inserted at about same distance from *SB* as are *ALs.* Usurped setae virtually all caudal to apices of *PL;* first row containing 4 or 5 setae resembling *PLs* but a trifle shorter and less obviously branched. Usurped setae 17 to 20 in number, roughly arranged in 4 highly ir-

regular rows or groups. With distinct ridges anterior to sensillae bases. Sensillae clavate; 26 (excluding petiole, 30 including it) x 9.5 microns. Sensillae bases surrounded by an area free of punctae and scrobiculi. *Body setae:* Dorsal setae similar to scutal setae;



FIGS. 84-91.—*Gahrliepia* (*Gahrliepia*) *evansi*, new species.

about 18 or 20 in number (excluding those captured by scutum), not clearly arranged in rows. With about 52 to 56 ventral setae, of which 20 to 26 are postanals. True ventrals about 15 microns in length; thin; pinnae sparse. *Legs:* Coxae I and II as in *G. exilis*, new species.

STANDARD MEASUREMENTS IN MICRONS

	AW	PW	SB	ASB	PSB	A-P	AL	PL	D.S.	PW/Coxa II	PW/SD	PW/ASB	PW/Tarsus III
Holotype, U.S.A.T.C. No. 561-1	40	56	34	19	136	30	22	26	24	56/46=1.22	0.36	2.9	56/43=1.31
Paratypes (3): Mean	40	60	37	19	134	32	23	26	24	1.20	0.39	3.2	1.36
Range + or −	1	4	3	1	5	2	3	3	4	0.04	0.04	0.3	0.05

Coxa III (fig. 85) relatively broad, four-fifths (or greater) as broad as long; with a prominent lobe at posterolateral angle (ratio of length to breadth, 50:45=1.1); the single seta submedial in insertion. With sternal setae and sensory setae essentially as in *G. exilis,* new species.

Type material.—Holotype (U.S.A.T.C. No. 561-1) ex *Rattus* sp., North Burma, 20 miles northwest of Myitkyina on Mogaung Road, January 24, 1945 (U. S. A. Typhus Commission). Three paratypes as follows: 1, ibid., but ex another *Rattus* (U.S.A.T.C. No. 552-23); 1, ibid., but ex *Rattus r. sladeni* (Anderson), May 22 (U.S.A.T.C. No. 1035-10); 1 same as the last but from a second individual (U.S.A.T.C. No. 1044-13). Holotype (U.S.N.M. No. 2164) and one paratype deposited in U. S. National Museum. Two paratypes in collection of senior author.

Comment.—The specimens were all collected in the primary forest or at the periphery of such true jungle. The species is named for Thomas M. Evans of the Department of Entomology, Army Medical Service Graduate School, Washington, D. C., who prepared the illustrations for this paper, and whose very fine drawings have done much to enhance the knowledge of Indo-Malayan trombiculid and laelaptid mites.

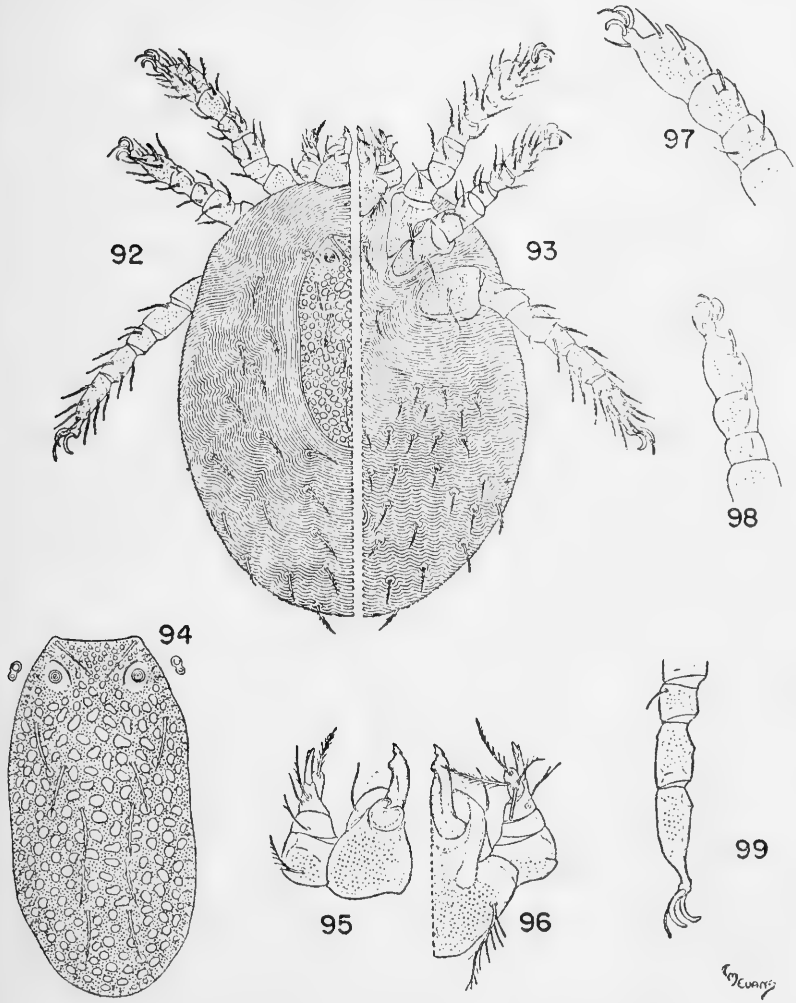
GAHRLIEPIA (GAHRLIEPIA) PICTA, new species

Figures 92-99

Diagnosis of larva.—Separable from the described Asian *Gahrliepia* possessing scrobiculate scuta in that there are 8 usurped scutal setae (not 4, or else 17 or more) and in that these are all medial. Further distinguishable from *G.* (*G.*) *evansi,* new species, in that the scutal scrobiculi are not all evenly ovate or elliptical but instead are often somewhat ameboid, trigonal or subquadrate or otherwise irregular.

Description of larva.—Body: Subovate, about 423 x 282 microns in fairly engorged holotype. Eyes apparently double. *Gnathosoma:* Chelicerae about four to five times as long as broad; apex of distal tricuspid cap long, acuminate; with a distinct nubbin somewhat proximad of base of cap. Palpal setal formula *b/b/b?Nb.* Palpal claw 3-pronged. *Scutum:* Long, broadly and evenly tongue-shaped; 179

x 92 microns at maxima (in holotype). Anterior margin straight. "Shoulders" at insertion of *ALs* inconspicuous. Posterior margin broadly and evenly rounded. Lateral margins somewhat flattened



FIGS. 92-99.—*Gahrliepia* (*Gahrliepia*) *picta*, new species.

medially; remainder evenly but shallowly convex. Micropunctations uniformly distributed except for around *SB*. Scrobiculi conspicuous, extending over scutum behind *SB;* in general about equal in diameter of sclerotized portion of sensillae bases or approximately six times diameter of setal bases. Scrobiculi usually subovate or irregularly

elliptical or slightly ameboid; at times trigonal or subquadrate; largest ones medial; the dimples anterior to *SB* are about one-fourth length of those between *PLs*. *AL* setae at anterolateral angles of scutum; fairly thin and sparsely plumed; branches inapparent. Submarginally inserted *PL* setae about one and a half times as long as *ALs;* otherwise similar. The four pairs of dorsal setae usurped by scutum all fairly near midline; anteriormost pair inserted about one-third of distance from anterior margin; fourth pair midway between third pair and posterior margin of scutum. Usurped setae morphologically resembling *ALs*. Sensillary bases surrounded by a small area free of punctae or pits; closer to *AL* than *PL*, the *SB-AL* distance about one-half that of *SB-PL*. With a lightly sclerotized ridge anterior to

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype, C.O.M.R.U. No. 25369	42	69	44	19	160	41	26	34	31	69/50=1.38	0.38	3.6	69/53=1.31
Paratypes (2): Mean	42	70	40	19	162	41	26	33	30	1.41	0.38	3.6	1.36
Range + or −	2	1	1	1	3	1	2	1	3	0.04	0.01	0.2	0.05

SB. Sensillae absent in specimens extant. *Body setae:* Dorsal setae resembling scutal setae; about 30 to 32 in number (excluding those on scutum); arranged 2.4(2).4(2).(2).6(2), the rest irregular. With about 48 to 50 ventral setae, of which about 22 are postanals. True ventrals very thin and small, about 15 microns in length; pinnae inapparent. *Legs:* Sensory setae, sternal setae and coxae I and II as in *G. exilis*, new species. Coxa III resembling *G. evansi*, new species, but caudolateral lobe not as well developed; in ratio 60 (length) : 46 = 1.30. Empodium or middle claw of tarsus exceptionally thin and setaceous; usually missing.

Type material.—Holotype (C.O.M.R.U. No. 25369) and one paratype ex *Rattus bowersi* Anderson, Malaya, Selangor, Ulu Langat Forest Reserve, March 4, 1952 (J. R. Audy, for Colonial Office Medical Research Unit). One paratype, ibid., but ex *Rattus sabanus* (Thomas), August 12. Holotype (U.S.N.M. No. 2165) deposited in U. S. National Museum. One paratype in collection of Colonial Office Medical Research Unit, Kuala Lumpur, and one in that of senior author.

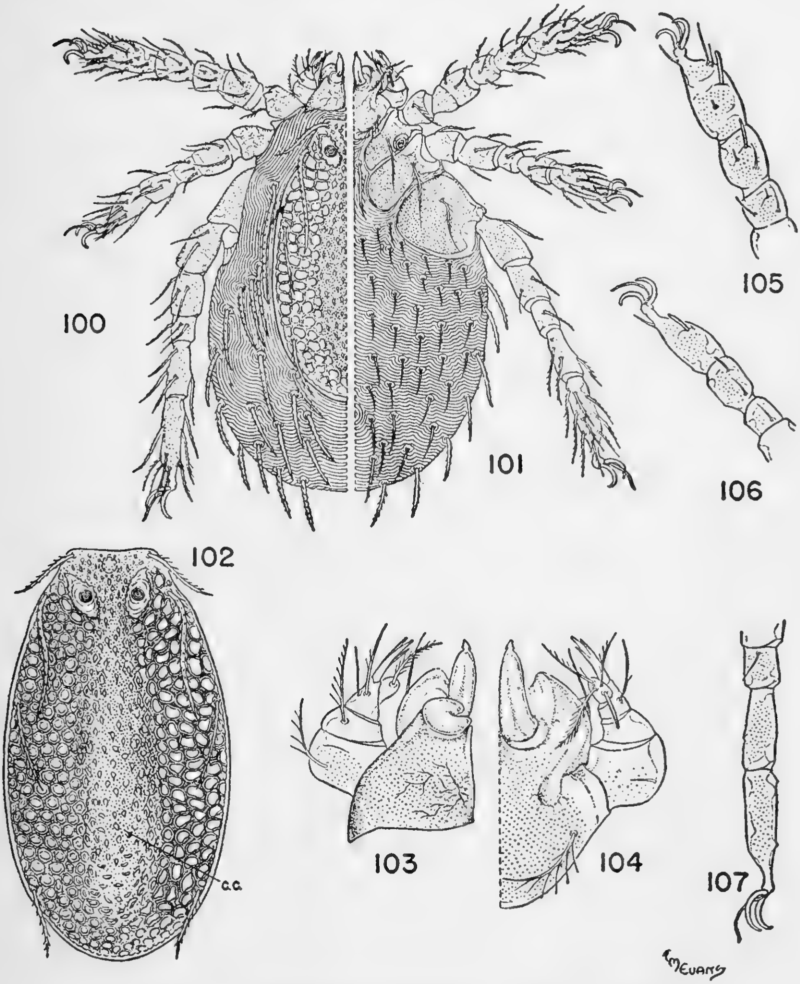
Comment.—This species has been taken only in the primary forest.

GAHRLIEPIA (GAHRLIEPIA) TESSELLATA, new species

Figures 100-107

Diagnosis of larva.—A scrobiculate species with enormously broad coxa III and with but 2 pairs of usurped setae on the scutum, which

also are marginal, thereby agreeing with the three "ornate" species described by Womersley in 1952: *insigne, decora,* and *ornata.* Immediately separable from *insigne* and *ornata* in the shape, size, and dis-



FIGS. 100-107.—*Gahrliepia* (*Gahrliepia*) *tessellata,* new species.

tribution of the scutal pits or scrobiculi. In the new species the scrobiculi at their maxima are about six or seven times the diameter of the setal bases, not 15 to 20 (cf. figs. 102, 174, and 184). Near *G. decora* but distinguished as follows: With two distinct sizes of scrobiculi—one along medial third of scutum and the second type on each side of this. The group along midline consisting of trigonal,

subquadrate, or rhomboidal pits which are only one-third to one-half the diameter of the ovoid scrobiculi on lateral thirds of scutum. In *G. decora* (fig. 182) the medial pits are subequal in size to the lateral ones. In the new species the *PLs* are in a line with *SB*, instead of being well anterior to *SB* as in *decora*.

Description of larva.—Body: Ovate, about 363 x 205 microns in rather engorged holotype. Eyes inapparent in specimens extant. *Gnathosoma:* Chelicerae about five times as long as broad at base; with typical tricuspid cap. Cheliceral bases and palpal coxae and femora heavily punctate. Palpal formula *B/B/bNb.* Palpal claw 3-pronged but usually appearing 2-pronged; middle prong slightly longer than others. *Scutum:* Long, broad, and evenly tongue-shaped; 266 x 166 microns at maxima in holotype. Anterior margin almost straight. "Shoulders" at anterolateral angles undeveloped. Lateral margin shallowly convex except between *AL-PL*, where it is slightly concave. Posterior margin evenly rounded. Uniformly micropunctate except for elliptical region around *SB* and for scrobiculi. Highly ornamented by virtue of the scrobiculi which extend over entire scutum. These scrobiculi of two types—medial and lateral. Medial pits forming a broad "central core" (fig. 102, *C.C.*) along longitudinal midline of scutum and consisting usually of small ellipses, or trigonal or subquadrate scrobiculi about twice the diameter of pores of dorsal setae. Lateral thirds of scutum covered with scrobiculi two to three times the diameter of those in median core; scrobiculi dorsally subovate (as in fig. 102, right side), but at a more ventral depth of focus, scrobiculi are definitely hexagonal (as depicted in fig. 102, left side) and are even set in a mosaic pattern. Pits between and anterior to *SB* generally resembling those of central group. *AL* setae fairly stout; sparsely plumed. Bases of *PLs* just below those of sensillae. *PL* setae resembling *ALs* but almost twice as long. The two pairs of scutal setae usurped from dorsal rows; marginal; resembling *ALs*. First pair of usurped setae (*PPL-1*) inserted slightly above level of midpoint of coxa III; *PPL-2* inserted at apical fifth. Sensillae bases surrounded by a well-delineated, ovate, oblique, unadorned area. Sensillae missing in specimens extant. *PPW-1* is 132 ($\pm$10); *PPW-2*, 126 ($\pm$9); *PPP-1*, 165 ($\pm$15); *PPP-2*, 36 ($\pm$5). *Body setae:*

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	$\frac{PW}{\text{Coxa II}}$	$\frac{PW}{SD}$	$\frac{PW}{ASB}$	$\frac{PW}{\text{Tarsus III}}$
Holotype, No. 8160-1 *	37	73	38	26	240	23	54	94	92	70/73=0.96	0.27	2.7	73/79=0.92
Paratypes (6): Mean	34	66	35	27	240	25	56	97	85	0.97	0.21	2.5	0.83
Range + or —	4	7	3	2	10	2	4	6	10	0.07	0.06	0.2	0.09

* Traub collection.

Dorsal setae similar to scutal setae; about 34 to 36 in number excluding those usurped by scutum. The great breadth of scutum resulting in crowding of dorsal setae along sides of body; rows hence inapparent. With about 82 ventral setae, including 6 which are in line with midpoint of coxa III and thus replace true sternals, and also including about 24 to 26 postanals resembling caudalmost dorsals. True ventral setae about 17 to 26 microns in length, thin, sparsely plumed. With a typical pair of sternal setae inserted in line with caudal angle of coxa I. *Legs:* Coxae particularly heavily punctate, appearing shagreened or beaded. Coxae II and III exceptionally broad (as in *G. ornata* Womersley, 1952, and allies). Thus, coxa III actually broader than long (ratio 86 to 93=0.92); with seta submedian. Sensory setae as in *G. exilis,* new species.

Type material.—Holotype (No. 8160-1) and three paratypes ex *Lariscus insignis* (Cuvier), a ground-dwelling squirrel, Malaya, Selangor, Gombak Forest Reserve, 16 miles north of Kuala Lumpur, near Pahang Road (R. Traub, for U. S. Army Medical Research Unit), July 7, 1948. One paratype (drawn in figs. 100-107) ex *Hylomys suillus* Müller, the lesser gymnuran, Malaya, Selangor, Ulu Langat Forest Reserve (J. R. Audy, for Colonial Office Medical Research Unit). Three ex *Rattus bowersi* Anderson, Ulu Langat, February 8, March 4, and October 14, 1952. Holotype (U.S.N.M. No. 2166) and one paratype deposited in U. S. National Museum. Paratypes deposited in collection of Colonial Office Medical Research Unit and in that of senior author.

Comment.—This species has been taken only in primary forest.

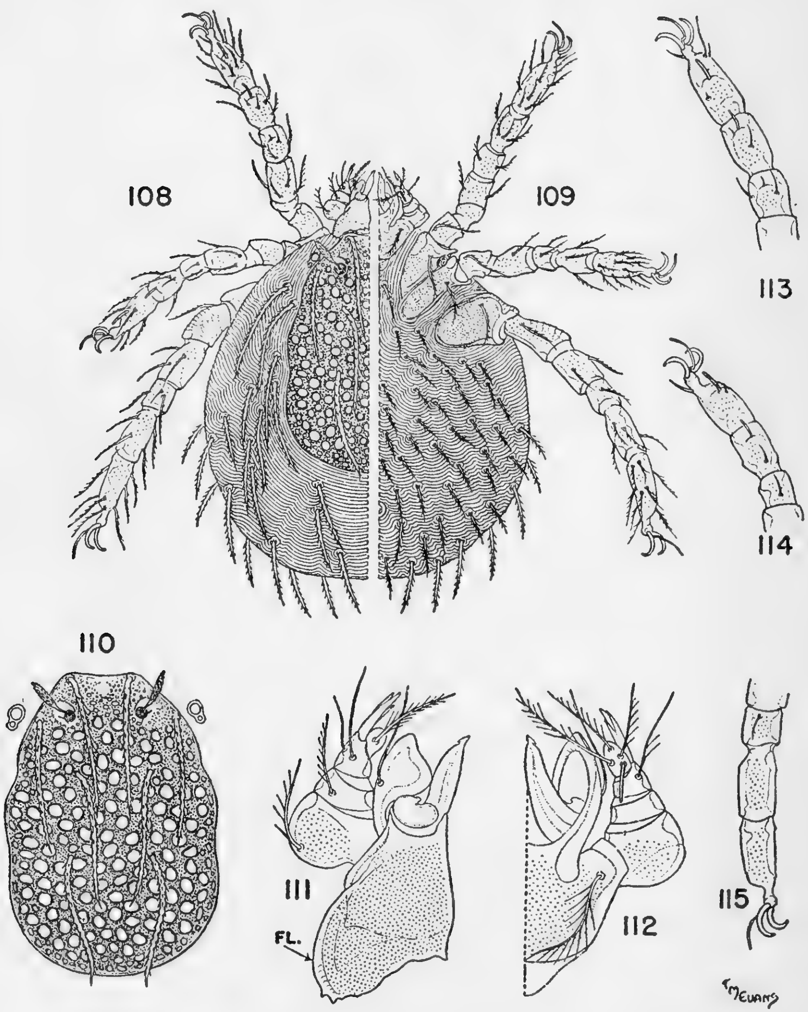
GAHRLIEPIA (GAHRLIEPIA) LACINIATA, new species

Figures 108-115

Diagnosis of larva.—Unique in possessing a prominent dorsal flap extending from each cheliceral base (fig. 111, *FL*). Distinctive among described scrobiculate *Gahrliepia* in that the scutum bears 2 pairs of usurped setae which are medial in position (thereby agreeing with 2 new ones described below). Resembling *G.* (*G.*) *picta,* new species, in that the scrobiculi are fairly large and distributed over most of scutum. Further separable from *G. picta* in that the pits are mainly subcircular instead of elliptical or ameboid, and by virtue of the great breadth of the scutum (ratio of scutal depth to width is 1.3, and not 2).

Description of larva.—Body: Ovate, about 408 x 304 microns in fairly engorged holotype. Eyes double; apparent as a raised, bead-

like structure inserted near level of *SB*. *Gnathosoma:* Chelicerae long and narrow, apically acuminate; about six times as long as broad at base; cheliceral bases modified, possessing a posterolateral exten-



FIGS. 108-115.—*Gahrliepia (Gahrliepia) laciniata,* new species.

sion in the form of a conspicuous dorsal flap which is basally thickened and apically produced into a broad flange. Palpal setal formula *B/B/NNb*. Palpal claw 3-pronged. *Scutum:* Very long, as in other species in subgenus, but relatively quite broad; 234 x 165 microns in holotype. Anterior margin somewhat concave. Lateral margins some-

what sinuate beyond *PLs*. Posterior half to two-thirds of scutum of fairly uniform breadth. Caudal margin very broadly rounded. Scutum appearing reticulated by virtue of prominent subcircular scrobiculi scattered over entire surface. Majority of pits (approximately 110 in number) subequal in size and about two and a half to three times the diameter of setal bases; smallest scrobiculi near margins of scutum, and these are flattened ellipses or oblate spheroids. With the usual micropunctae uniformly distributed over remainder of scutum except for a narrow bare area around sensillae bases. *AL* setae inserted slightly behind low "shoulders" at anterolateral angles of scutum; fairly stout and bushy; quite long, extending to about midpoint of scutum; subequal to *PL* in length. *PLs* inserted at level of about anterior fifth of scutum; resembling *ALs*. First pair of usurped setae (*PPL-1*) inserted at level of anterior third of scutum and in vertical line with sensillae bases; resembling *PLs* but even longer (118 microns). *PPL-2* at posterior third; in line with *SB* and *PPL-1*, similar to *PLs* in morphology and in length. Sensillae bases inserted slightly anterior to line of *PLs*. Sensillae narrowly clavate; most of club cylindrical in shape. With a weakly sclerotized ridge anterior to each sensillary base. *PPW-1* is 55 ($\pm$6); *PPW-2*, 52 ($\pm$13); *PPP-1*, 159 ($\pm$8); *PPP-2*, 94 ($\pm$6). *Body setae:* Dorsal setae

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	$\frac{PW}{\text{Coxa II}}$	$\frac{PW}{SD}$	$\frac{PW}{ASB}$	$\frac{PW}{\text{Tarsus III}}$
Holotype, No. B-19365-5 ...	42	104	59	28	216	45	120	123	105	104/82=1.27	0.43	3.7	104/70=1.49
Paratypes (20):													
Mean	43	103	58	28	216	43	119	126	119	1.31	0.42	3.6	1.44
Range + or —	5	8	6	2	20	7	11	13	6	0.09	0.02	0.3	0.05

resembling scutal setae; about 26 to 30 in number (excluding those captured by scutum); rows obscure, but apparently arranged 2.2.8 (2).8(2), the rest irregular. With about 70 to 76 ventral setae, of which about 24 are postanals but which nevertheless are shorter and distinctly thinner than dorsals. True ventrals thin, short, about 18 microns in length, sparsely plumed. Sternal setae arranged 2-4(5), the latter row resembling ventrals. *Legs:* Coxa I with a distinctive spur at caudolateral angle. Coxa III about one and a half times as long as broad (71 by 46 microns=1.54 in holotype). With seta submarginal in position. Sensory setae essentially as in *G. exilis*, new species.

Type material.—Holotype (No. B-19365-5) ex *Rattus alticola alticola* Thomas, North Borneo, Mount Kinabalu, Mari Parei, elevation 5,100 feet (R. Traub, for joint U. S. Army-Colonial Office

Medical Research Unit), August 25, 1953. Ten paratypes, ibid.; 46 paratypes with same data (No. B-19370); 18 paratypes, ibid., but at Tenompak, 4,500 feet, August 20, 1953 (No. B-19319); 2 paratypes as No. B-19319 but collected July 16, 1951; 22 paratypes as No. B-19319 but collected August 31, 1953; 3 as No. B-19319 but collected September 1, 1953; 1 paratype, ibid., but ex *Rattus* of the *rajah* group, Tenompak, 4,500 feet, July 19, 1951; 1 paratype, ibid., but ex *Rattus rapit* Bonhote, at Tenompak, 4,000 feet, August 29, 1953 (No. B-19412); 10 paratypes, ibid., but ex *Rattus sabanus,* at Tenompak, 4,500 feet, August 29, 1953 (No. B-19414). Holotype (U.S.N.M. No. 2167) deposited in U. S. National Museum. Paratypes distributed as for *G. exilis.*

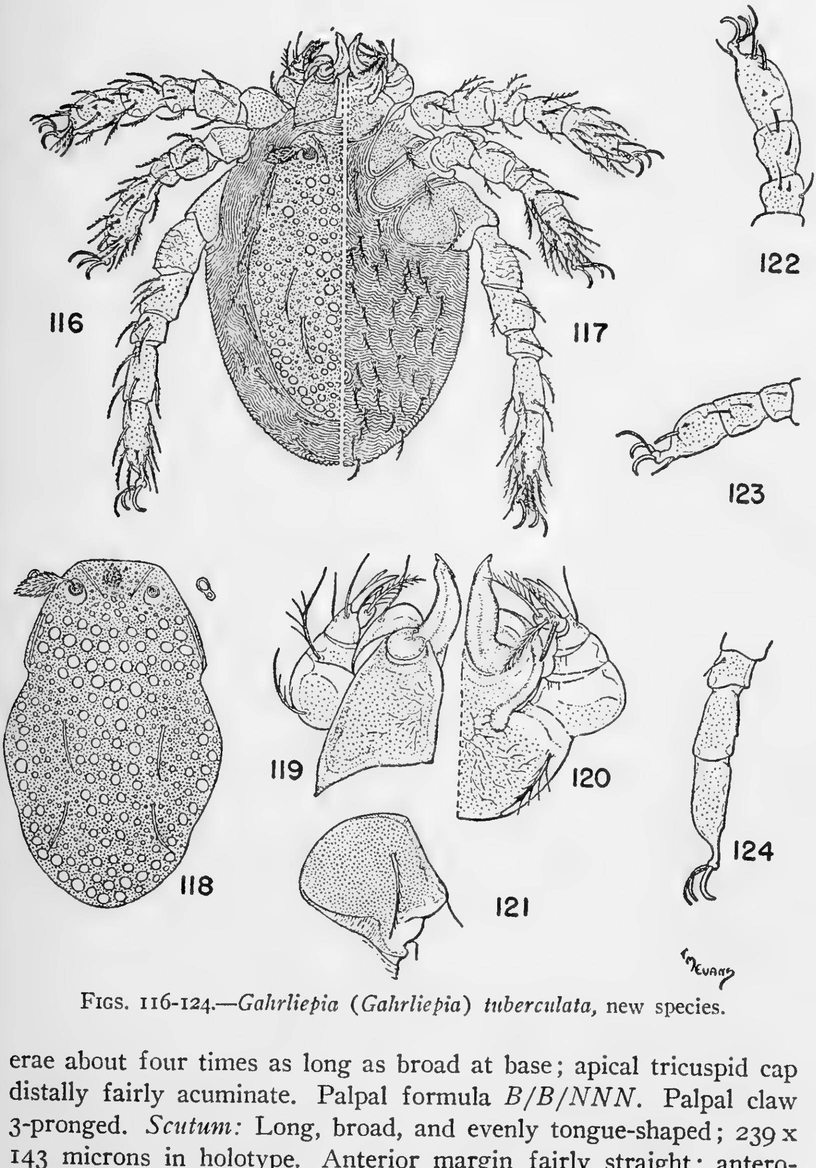
Comment.—Gahrliepia laciniata, new species, exhibits an interesting and specific preference regarding site of attachment on the host. Virtually every specimen was found firmly attached at the bases of vibrissae and adjacent short hairs or spines on the muzzle of the rat. Invariably the chigger was solitary, and frequently was standing vertically, dorsally appressed to the stout hairs and hence difficult to see. Once this attachment site was discovered (in 1953), it was easy to collect this chigger which had previously been considered rare. Thus, only three specimens were collected by the 1951 expedition and none in 1952. Over 90 percent of the records are from *Rattus alticola.*

GAHRLIEPIA (GAHRLIEPIA) TUBERCULATA, new species

Figures 116-124

Diagnosis of larva.—Agrees with *G. laciniata,* new species, regarding presence of a scrobiculate scutum and 4 submedian usurped setae. Readily separable as follows: Lacking a flap extending from about the cheliceral bases. *PL* setae shorter than 40 microns and about twice the length of *ALs,* instead of being over 110 microns in length and subequal to *ALs.* Scutum subovate, becoming narrow at distal third; relatively longer (ratio of *SD* to maximum width is 1.5 to 1.6), whereas in *G. laciniata* the scutum is evenly broad until near caudal margin, and the ratio *SD* to maximum width is 1.3. In the new species the large scrobiculi are not evenly distributed over the scutum but instead are most conspicuous (and largest) along the longitudinal midline or core. Another group of large scrobiculi border the lateral margins. There is, therefore, a narrow, relatively nonornate gap between the marginal group and the imaginary vertical line linking each *PPL.* In *G. laciniata* the large dimples are subequal in size and uniformly pit the scutum.

Description of larva.—Body: Remarkably ovate caudad of insertion of leg III. About 351 x 206 microns in somewhat engorged holotype. Eyes double, but posterior eye reduced. *Gnathosoma:* Chelic-



FIGS. 116-124.—*Gahrliepia (Gahrliepia) tuberculata*, new species.

erae about four times as long as broad at base; apical tricuspid cap distally fairly acuminate. Palpal formula *B/B/NNN*. Palpal claw 3-pronged. *Scutum:* Long, broad, and evenly tongue-shaped; 239 x 143 microns in holotype. Anterior margin fairly straight; anterolateral margins rounded. Lateral margins gently sinuate; slightly

flared distal of midpoint. Caudal margin evenly convex. With large ovate pits or scrobiculi scattered over most of scutum. Largest scrobiculi in core region, about 10 microns in length (about four times diameter of base of scutal seta). Typical submarginal scrobiculi subequal to medial group. Pits in intermediate region only about 3 to 4 microns in diameter, as are those between and anterior to *SB*. With micropunctae scattered over remainder of scutum. *AL* setae almost in vertical line with *SB;* "shoulders" undeveloped at point of insertion. *AL* setae fairly short, thin, sparsely plumed. *PL* setae similar but about twice as long. The 2 pairs of usurped setae submedial in position; resembling true scutal setae. The distance from *PL* to *PPL-1* about one and a half times that from *PPL-1* to *PPL-2*. Sensillary bases slightly closer to line of *ALs* than *PLs*. With an inconspicuous ridge anterior to sensillary bases. Sensillae clavate, three and a half to four times as long as broad (excluding petiole). With 2 or 3 pairs of dorsal setae contiguous to lateral margin of scutum; at times these appearing as if on scutum, especially since margins of dorsal plate frequently excised at these sites. *PPW-1* is 61 (±7); *PPW-2,* 50 (±6); *PPP-1,* 115 (±10); *PPP-2,* 60 (±7). *Body setae:* Dorsal

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype, No. B-19327-7	43	91	50	20	219	40	20	37	40	91/66=1.38	0.30	4.6	91/67=1.36
Paratypes (20): Mean	43	94	48	18	211	40	18	36	38	1.40	0.39	5.2	1.45
Range + or −..........	4	8	3	2	11	4	5	3	5	0.05	0.10	0.6	0.09

setae resembling *PLs* but slightly stouter; about 14 to 18 (usually 16) in number, generally well spaced on dorsum, appearing singly rather than in horizontal or arched rows. With about 64 to 70 ventral setae of which about 20 are postanals but nevertheless considerably smaller than dorsals. True ventrals about 16 to 18 microns in length, thin, very sparsely plumed. *Legs:* Coxae heavily punctate, shagreened. Coxa III with seta inserted in anterolateral quadrant but nonmarginal; very broad (fig. 121; cf. fig. 9 for more typical *G. exilis*)—ratio of coxal length to width, 71 to 66=1.1. First pair of sternal setae about 29 microns in length; second pair about 21 microns, its base at level of midline of coxa III. Sensory setae as in *G. exilis,* new species.

Type material.—Holotype (No. B-19327-7) ex *Rattus whiteheadi whiteheadi* Thomas, North Borneo, Mount Kinabalu, Tenompak, elevation 4,500 feet (R. Traub, for joint U. S. Army-Colonial Office Medical Research Unit), August 21, 1953. Paratypes as follows: 1,

ibid.; 1, ibid., but August 17, 1953; 2, ibid., but ex *Rattus sabanus,* September 21, 1953 (No. B-19476); 1, ibid., but ex nest of *Rattus* sp., August 20, 1953; 2, ibid., but ex *Rattus rajah* at Paring, elevation 1,600 feet, July 18, 1953 (No. B-19058); 34, ibid., but ex *Rattus müelleri,* 10 miles north of Jesselton at Menggatal Estate, August 4, 1951 (No. B-9108); 1, ibid., but Ranau, elevation 1,500 feet, July 15, 1953 (No. 20523); 3, ibid., but *Rattus* sp., Ranau, elevation 1,500 feet, July 28, 1953 (No. B-19151). Holotype (U.S.N.M. No. 2168) deposited in U. S. National Museum. Paratypes distributed as for *G. exilis.*

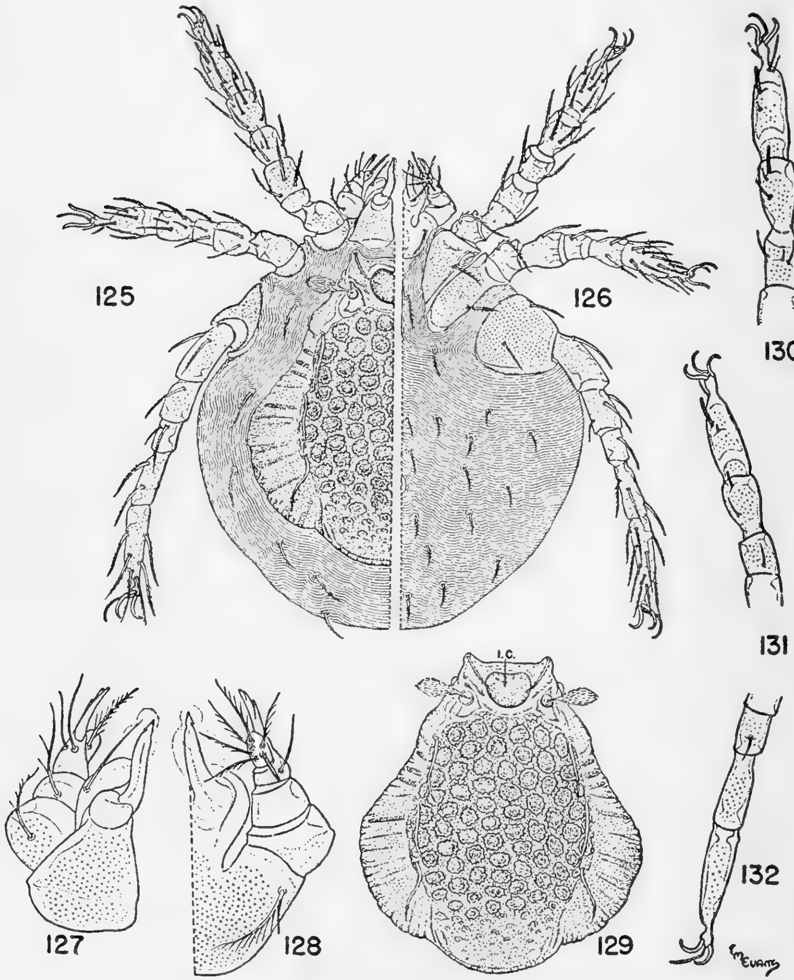
GAHRLIEPIA (GAHRLIEPIA) AMPULLATA, new species

Figures 125-132

Diagnosis of larva.—Unique among those scrobiculate *Gahrliepia* which possess 4 usurped setae in that the scutum is shaped like a very broad flask and bears deep marginal scallops (fig. 129). Also distinctive by virtue of the crenulate scrobiculi adorning the nonscalloped portion of the scutum. Separable from the other species known for the subgenus (but agreeing with the new species next described) by the following: With 2 setae on coxa III; with an intersensillary crater (i.e., a massive scrobiculus between sensillae bases and extending to near anterior margin) (fig. 129, *I.C.*); scutum at its maximum nearly as broad as long; with the eyes contiguous with scutum.

Description of larva.—*Body:* Relatively broadly ovate, much rounder than is typical for the genus; 327 x 260 microns in rather engorged holotype. Eyes bordering scutum at level of sensillae; appearing single, posterior eye almost vestigial. *Gnathosoma:* Chelicerae about four times as long as broad at base; with apical tricuspid cap distally acuminate. Palpal formula: *B/b/NNN.* Palpal claw 3-pronged; lateralmost prong two-thirds length of mesal one. *Scutum:* Long, but very broad at apical third; 230 x 203 microns; shaped like a broad flask with subrounded base. Lateral and caudal margins relatively well sclerotized; with a flange of deep scallops set off by transverse striations. The apical scallops about one-fifth or one-sixth the breadth of the scutum. Remainder of scutum with irregular rows of conspicuous crenulate scrobiculi which are four to five times the diameter of the setal bases; the pits distributed equally over entire scutum between level of *SB* and caudal margin. Caudomarginal scrobiculi crowded, smaller, contiguous and indistinct. With an enormous scrobiculus, the intersensillary crater (fig. 129, *I.C.*) dominating the scutal region between and in front of *SB.* Minutely punctate

between pits and on scalloped portion. *AL* setae short, fairly thin, and weakly pinnatifid. *PLs* about subequal to *ALs* and otherwise similar; the distance *A-P* about equal to *AL* and *PL*. *PPL-1* and



FIGS. 125-132.—*Gahrliepia* (*Gahrliepia*) *ampullata*, new species.

PPL-2 resembling *PLs*, but *PPL-2* slightly shorter. Usurped setae fairly well removed from margin. The distance between *PPL-1* and *PPL-2* equal to that between *PPL-1* and *PL*. Sensillary bases at level midway between *AL* and *PL*; inserted on a somewhat semicircular plate whose anteromesal margins constitute the characteristic antesensillary ridges. Sensillae clavate; somewhat fusiform; about

three and a half times as long as broad, excluding long petiole (dimensions, with petiole: 38 x 9.5 microns). *PPW-1* in holotype is 120; *PPW-2*, 118; *PPP-1*, 127; *PPP-2*, 75. *Body setae:* Dorsal setae

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype, No. B-19409-3	58	96	57	32	197	63	28	50	27/30	96/70=1.37	0.42	3.0	96/64=1.5
Paratypes (5): Mean	58	98	59	32	196	60	29	55	23/32	1.40	0.44	3.0	1.5
Range + or −	2	4	6	1	8	4	2	5	4	0.06	0.05	0.05	0.04

greatly reduced in number, apparently because of enlarged scutum; only 10 in number (excluding those usurped by scutum) and these submarginal, short (20 to 47 microns), sparsely plumed. With only about 34 ventral setae, including about 18 postanals. True ventrals about 24 microns in length, thin and with few pinnae. Sternal setae 2-2. *Legs:* Coxae I and II as in *G. exilis*. Coxa III relatively broad, almost as broad (54 microns) as long (59 microns); with 2 setae, one anteromarginal and sublateral, the second submedian. Sensory setae as typical for genus.

Type material.—Holotype (No. B-19409-3) ex *Rattus whiteheadi whiteheadi* Thomas, North Borneo, Mount Kinabalu, Tenompak, elevation 4,500 feet (R. Traub, for joint U. S. Army-Colonial Office Medical Research Unit), August 29, 1953. Four paratypes with same data; a fifth, ibid., but July 16, 1951, and from the same host or from *Rattus cremoriventer kina* Bonhote. Holotype (U.S.N.M. No. 2169) and one paratype deposited in U. S. National Museum. One paratype in collection of Colonial Office Medical Research Unit, Kuala Lumpur. Remainder in collection of senior author.

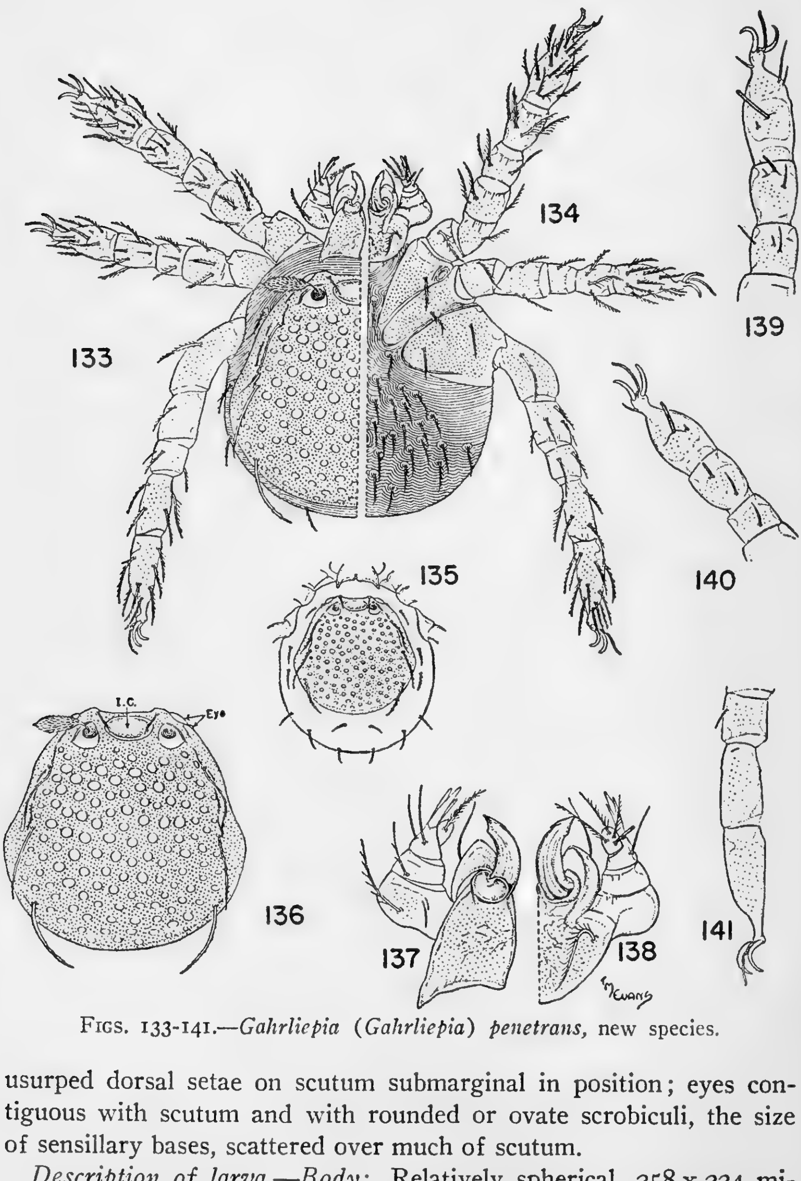
Comment.—The possibility that this is a chigger that burrows into the subcutaneous tissues of the host is discussed after the description of the next species, a true burrowing form.

GAHRLIEPIA (GAHRLIEPIA) PENETRANS, new species

Figures 133-141

Diagnosis of larva.—Unique in the genus in that the scutum at its maximum is as broad as long, instead of being one and a quarter to two times as long as broad. Separable from known *Gahrliepia*, except for *G.* (*G.*) *ampullata*, new species, by each of the following: With 2 setae on coxa III; eyes contiguous with scutum; with an intersensillary crater, i.e., a huge scrobiculus extending from level of *SB* to near anterior margin (fig. 136, *I.C.*). Readily distinguishable from

G. ampullata, new species, in that the scutum lacks marginal scallops and in that the margins of the scrobiculi are also smooth, not crenulate. Further diagnosed by the spherical body, the presence of 4



FIGS. 133-141.—*Gahrliepia (Gahrliepia) penetrans,* new species.

usurped dorsal setae on scutum submarginal in position; eyes contiguous with scutum and with rounded or ovate scrobiculi, the size of sensillary bases, scattered over much of scutum.

Description of larva.—Body: Relatively spherical, 258 x 224 microns when moderately engorged. Eyes double; posterior eye greatly

reduced; lying against scutum at anterolateral angles. *Gnathosoma:* Cheliceral bases caudally emarginate and with laterocaudal angles produced, accentuated. Chelicerae about four to five times as long as broad at base; with a distinct apical acuminate cap. Palpal setal formula: *B/B(b)/NNN*. Palpal claw 3-pronged. *Scutum:* Long and relatively very broad; about 165 x 169 microns (holotype). Anterior margin slightly concave. Broadest at distal two-fifths; virtually covering entire dorsum in unengorged specimens (as fig. 133). Caudal margin broadly and evenly convex. Lateral margins somewhat sinuate to point of maximum width. The punctations of scutum interspersed among irregular rows of circular or subovate scrobiculi, which are about 80 in number and subequal to sensillary bases. With conspicuous sclerotized lines or seams connecting bases of *ALs* with *PLs* and with first pair of usurped setae. The scrobiculi restricted to that part of the scutum encompassed by these sclerotized lines and by the levels of the usurped setae; evenly scattered within this area; the smaller pits nearer the margins. Region between sutures and true margins of scutum evenly punctate. Intersensillary crater about 14 by 29 microns. *AL* setae small, not extending beyond posterior margin of crater; thin and weakly pinnatifid; displaced from anterolateral angles and actually somewhat nearer to midline than are *SBs*. *PL* setae submarginal, inserted twice as far from *SB* as are *ALs;* long, with appressed pinnae. *PW* about two and a half times *AW*. First pair of usurped setae somewhat more lateral than *PL* but equidistant from margin or slightly farther from margin, as far from *PL* as is *AL;* midway between *PL* and second pair of usurped setae, which usually is in line with *PL*. Usurped setae morphologically resembling *PLs*. Sensillary bases surrounded by a triangle of ridges, of which lateral ones are best developed. Sensillae clavate, with head about twice as long as broad. *PPW-1* is 123 (±7); *PPW-2*, 119 (±6); *PPP-1*, 86 (±5); *PPP-2*, 37 (±7). *Body setae:* Dorsal setae reduced in

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype, No. B-19389-5	38	104	51	15	150	49	14	55	23	104/73=1.43	0.63	6.9	104/53=1.96
Paratypes (18): Mean	39	101	51	16	147	46	14	54	24	1.45	0.63	6.8	1.84
Range + or −.......	2	4	3	2	6	4	2	3	3	0.09	0.05	0.06	0.12

number and size—true dorsals nearly always only 8 in number, but engorged specimens with 4 to 6 additional setae which usually appear marginal but which may actually be dorsal regarding insertion; true dorsals widely separated from one another; less than half length of

scutal setae; thin; very sparsely plumed. With about 42 ventral setae of which about 16 are postanals. True ventrals about 18 to 21 microns in length; thin; pinnae inapparent. *Legs:* Coxal setae all thin, weakly plumed. Coxa III with 2 setae, one near anterolateral angle, the second near base of coxa. Coxa III broad, in ratio of 66 (length) to 59 microns (=1.12). First pair of sternal setae with bases almost contiguous, about 28 microns in length. Second pair of sternals at level of coxa III; widely separated so that each is in line with base of coxa II; resembling coxal setae. Sensory setae as in *G. exilis,* new species.

Type material.—Holotype (No. B-19389-5) and 55 paratypes (No. B-19389) ex *Rattus whiteheadi whiteheadi* Thomas (completely embedded in female perineum), North Borneo, Mount Kinabalu, Mari Parei, elevation 5,100 feet, August 27, 1953 (R. Traub, for joint U. S. Army–Colonial Office Medical Research Unit). Two paratypes, ibid., but August 25, and recovered by washing the host by a modification of the Lipovsky detergent method (Lipovsky, 1951). One paratype, ibid., but at Tenompak, elevation 4,500 feet, August 29 (along with 5 *G. ampullata,* new species). Holotype (U.S.N.M. No. 2170) deposited in U. S. National Museum. Paratypes distributed as for *G. exilis,* new species.

Comment.—It is of interest that this species can burrow completely into the superficial skin tissues of the host. The No. B-19389 series was collected by dissection after noting that the surface of perineum of the rat was pock-marked by a series of smooth pores. The pores were thereupon enlarged by means of fine forceps or dissecting needles and the chiggers were found just below the opening. Except in the instance of unengorged (hence recently attached) chiggers, the chiggers were entirely within the pocket, and no part of the body protruded through the aperture. If present, the chiggers were solitary within these pockets. Many of the larger pores led to empty pockets, indicating that the chiggers had emerged. This burrowing phenomenon has not been noted for any other species of chigger by the American and British field teams in Assam, Burma, Malaya, or Borneo, and this is apparently the first report of a chigger which may characteristically burrow into mammalian tissues.[10] It is obvious, however, that a chigger that penetrates into the tissues of a host may readily escape detection, and other such species may in reality be common in nature. In this regard it should be pointed out that subsequent to the

[10] *Apolonia tigipioensis* Torres and Braga, 1939, penetrates the quills of South American birds and has been once reported as having entered the skin on the buttocks of a human in Brazil (Carneiro, 1949).

discovery of the burrowing habit of *G. penetrans,* new species, particular attention was paid to examining the perinea of Borneo rats, squirrels, and other hosts by means of the stereoscopic microscope. Despite the examination of 150 such mammals from Mari Parei, Tenompak, and Ranau, no such overt lesions were observed and no further specimens were collected other than the type series.

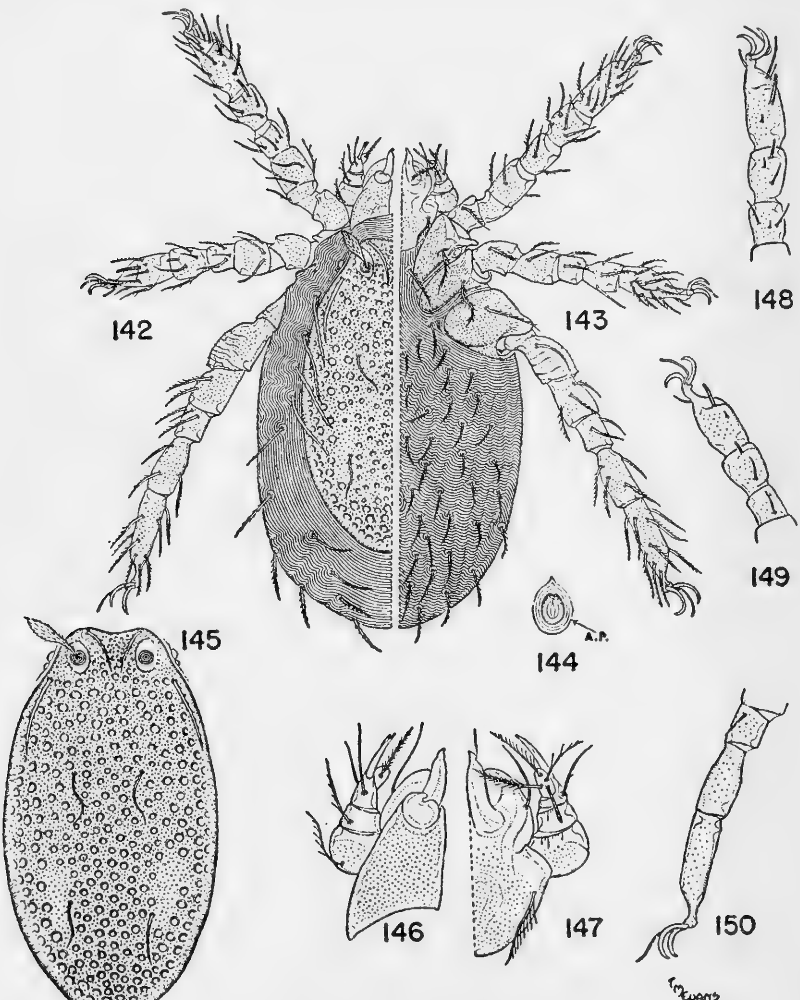
G. penetrans, new species, exhibits some noteworthy morphological modifications that are characteristic of the species and rare or absent in other members of the subgenus. These are: (1) The body is quite rounded, virtually as broad as long even when rather engorged. (2) The eyes appear single and are contiguous with the scutum. (3) The laterocaudal angles of the cheliceral bases are prominently developed. (4) *PW* is two and a half times that of *AW,* instead of being about twice that. (5) The ratio of *PW* to *ASB* is 6.8 instead of the usual 2-3 (with a maximum of 5) in other species. (6) The reduction in the number and size of the dorsal setae. (7) Two-setose coxa III. The first six of these modifications may be adaptations in connection with, or as a result of, its burrowing habit. The stout body of this chigger and its locus in superficial skin layers is reminiscent of the engorged burrowing chigoe flea, *Tunga penetrans.* In each parasite, advantage is in effect taken of the physical principle that the ratio of surface area to volume is a minimum in a sphere. In other words, a spherical parasite packs the greatest possible volume in the smallest possible area, thus mechanically traumatizing the host the least, provided the parasite is stationary when in situ, as in these instances. Certain of these modifications are expressions of, or are concomitant with, the development of a spherical shape, i.e. (4) and (5), inasmuch as a broad *PW* is to be expected in a stout species. Loss of bristles, or reduction in their size, is characteristic of other ectoparasites with a burrowing or semisedentary habit, as exemplified by the tungid and hectopsyllid fleas.

In many respects *G. penetrans,* new species, resembles *G. ampullata,* new species. Thus in both species the highly scrobiculate scutum virtually covers the entire dorsum in unengorged specimens; the body is much more rounded than in other species; the eyes are contiguous with the scutum; there is an intersensillary crater; coxa III is 2-setose, and there has been a reduction in the number and size of dorsal setae as compared with others in the subgenus. *G. ampullata* has been collected only twice, despite extensive trapping of the type host in the type locality. It is possible that it, too, is a burrowing species and hence has been overlooked.

GAHRLIEPIA (GAHRLIEPIA) GRANULATA, new species

Figures 142-150

Diagnosis of larva.—Separable from other scrobiculate species in the subgenus that have 4 usurped dorsal setae on the scutum by the



FIGS. 142-150.—*Gahrliepia* (*Gahrliepia*) *granulata*, new species.

fact that the scrobiculi are almost uniformly scattered over the dorsal surface of the scutum and range from the size of the setal bases to that of the sensillary bases. Agrees with *G.* (*G.*) *tuberculata, G.* (*G.*)

penetrans, and *G.* (*G.*) *ampullata*, new species, in that *PW* is over 90 instead of below 80 as in other species. Nearest to *G. tuberculata* but significantly differs as follows: Although *AW* is approximately the same in both species, *ASB* 25 or greater in *granulata*, not approximately 18; *AL* over 40, not 18; *PL* over 60, not merely less than 40; *PSB* approximately 300, not 215. The long ovate scutum immediately distinguishes this species from *G. penetrans* and *G. ampullata* (cf. figs. 129, 136, and 145).

Description of larva.—*Body:* Subovate, about 473 x 252 microns in engorged holotype. Eyes double; anterior eye the larger. Chelicerae about three and a half times as long as broad at base; with a distinct distal tricuspid cap. Palpal setal formula: *B/B/NNf*. Palpal claw 3-pronged but usually appearing 2-pronged. *Scutum:* Long, ovate, about 329 x 182 microns in holotype. Anterior margin concave between *ALs*. Lateral margins slightly sinuate to level of *PLs;* remainder evenly but shallowly convex. Posterior margin short; convex. Interspersed among micropunctae is a fairly uniformly distributed series of subequal ovate scrobiculi most of which are about the size of sensillary bases; marginal craters or pits slightly larger than medial ones. Virtually entire scutal surface thus appearing granulated (although in reality pitted) or shagreened. The scrobiculi fewest in number in the region between the usurped setae and the group along lateral margins of the scutum. *AL* setae somewhat removed from anterolateral angles to a point just mesad to sensillary bases; stout and plumose but barbs short. *PL* setae similar but about one and a third times as long; inserted slightly farther from *SB* than are *ALs;* well lateral to level of *ALs*. Usurped setae roughly in line with *ALs;* first pair inserted approximately at anterior third of scutum; second pair slightly caudad of posterior third; each about 47 microns long, with pinnae appressed. With ridges anterior to sensillae bases. Sensillae clavate, about 49 x 9 microns. Sensillary area free of punctae and scrobiculi. *PPW-1* is 68 (±8); *PPW-2*, 70 (±5); *PPP-1*, 210

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW* / Coxa II	*PW* / *SD*	*PW* / *ASB*	*PW* / Tarsus III
Holotype, No. B-19601 ..	44	100	55	25	304	49	47	63	82 & 50	100/80=1.25	0.3	4.0	100/88=1.14
Paratypes (2):													
Mean	45	101	55	26	302	47	46	64	80 & 48	1.26	0.3	3.9	1.05
Range + or —...	1	2	3	1	5	2	3	3	5 & 4	0.03	0.03	0.1	0.09

(±10); *PPP-2*, 102 (±12). *Body setae:* Dorsal setae of two types —a line of 4 or 5 single large, stout setae bordering each side of middle third of scutum, about 80 microns in length; the remainder more

caudad and distant from scutum; about 50 microns and proportionately thinner. Dorsal setae about 28 in number; single or not arranged in rows except for those posterior to scutum, and those in 2 or 3 irregular rows. With about 62 ventral setae of which about 24 are postanals. True ventrals about 28 microns; thin; very sparsely plumed. With a suggestion of a small, ovate anal plate about 28 x 19 microns (fig. 144, *A.P.*) surrounding the chitinized anal ring. *Legs:* As in *G. exilis,* new species, but with coxa III much broader, ratio of length to breadth 90 to 75 microns = 1.2 (as measured to apex of caudolateral flange or lobe). Sternal and sensory setae essentially as in *G. exilis.*

Type material.—Holotype (No. B-19601) and one paratype ex *Rattus alticola alticola* Thomas, North Borneo, Mount Trus Madi, Pamang, Ulu Kaingaran, 4,000 feet elevation, July 18, 1953 (J. R. Audy, for joint U. S. Army-Colonial Office Medical Research Unit). Sixteen other paratypes from Mount Kinabalu, Tenompak, 4,200-4,500 feet elevation; 11 of these ex 4 *Rattus a. alticola,* August 12-21, 1953 (R. Traub); 1 ex *Rattus whiteheadi whiteheadi* Thomas, August 21; 1 ex *Rattus* sp., September 1, 1953 (R. Traub); 2 ex *Rattus a. alticola,* August 25 (H. D. Newson and B. C. Walton); 1 ex *Rattus a. alticola,* August 8 (Phang Ang Wah). Holotype (U.S.N.M. No. 2171) and one paratype deposited in U. S. National Museum. One paratype in collection of Colonial Office Medical Research Unit, Kuala Lumpur, and others in that of senior author or distributed among various acarological collections.

GAHRLIEPIA (GAHRLIEPIA) NANUS (Oudemans, 1910)

Figures 151-158

1910. *Typhlothrombium nanus* OUDEMANS, Ent. Ber. Amsterdam, vol. 3, No. 56, p. 105.

1911. *Typhlothrombium nanus* OUDEMANS, Oudemans, Ent. Ber. Amsterdam, vol. 3, No. 57, p. 122.

1912 *Typhlothrombium nanus* OUDEMANS, Oudemans, Zool. Jahrb., Suppl. 14, Heft 1, pp. 83-86, 192, 203, fig. U.

1930. *Typhlothrombium nanus* OUDEMANS, Stiles and Nolan, Nat. Inst. Health Bull. 155, pt. 1, p. 640.

1931. *Gahrliepia nana* (OUDEMANS), Vitzthum, Zeitschr. Parasitenk., vol. 4, No. 1, p. 7.

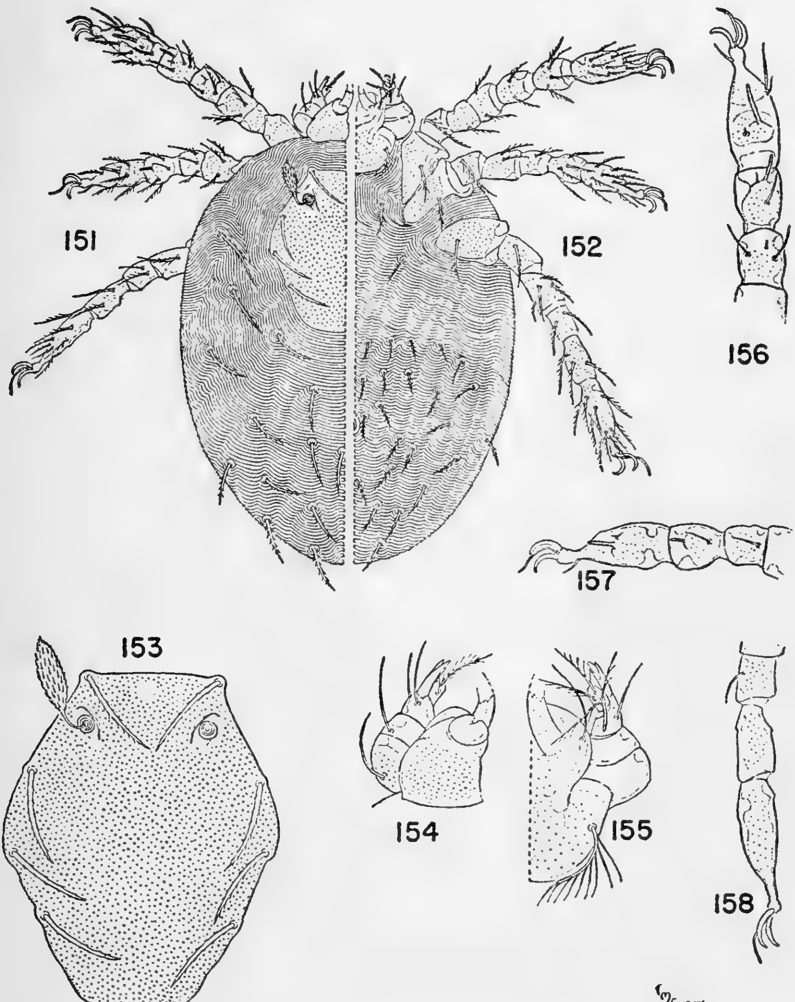
1938. *Gahrliepia nanus* (OUDEMANS), Ewing, Journ. Washington Acad. Sci., vol. 28, No. 6, pp. 291-292.

1939. *Gahrliepia nanus* (OUDEMANS), Abdussalam, Indian Journ. Ent., vol. 1, No. 3, pp. 83-86.

1940. *Gahrliepia nanus* (OUDEMANS), Gunther, Proc. Linn. Soc. New South Wales, vol. 65, pts. 5-6, Nos. 291-292, p. 481.

1942. *Gahrliepia nanus* (OUDEMANS), Radford, Parasitol., vol. 34, No. 1, p. 64, fig. 33.

1943. *Gahrliepia nanus* (OUDEMANS), Womersley and Heaslip, Trans. Roy. Soc. South Australia, vol. 67, No. 1, pp. 136, 138.



FIGS. 151-158.—*Gahrliepia* (*Gahrliepia*) *nanus* (Oudemans, 1910).

1945. *Gahrliepia nana* (OUDEMANS), Buitendijk, Zool. Meded., vol. 24, p. 337.

1947. *Gahrliepia nanus* (OUDEMANS), Sig Thor and Willmann, Trombidiidae, Das Tierreich, Lfg. 71b, p. 333, fig. 398, *a*, *b*, *c*.

1948. *Gahrliepia nanus* (OUDEMANS), Fuller, Bull. Brooklyn Ent. Soc., vol. 43, No. 4, p. 109.

1949. *Gahrliepia nanus* (OUDEMANS), Lawrence, Ann. Natal Mus., vol. 11, No. 3, pp. 409, 469.
1951. *Gahrliepia nanus* (OUDEMANS), Lawrence, Ann. Natal Mus., vol. 12, No. 1, p. 117.
1952. *Gahrliepia nana* (OUDEMANS), Wharton and Fuller, Mem. Ent. Soc. Washington, No. 4, p. 93.
1952. *Gahrliepia nanus* (OUDEMANS), Gunther, Proc. Linn. Soc. New South Wales, vol. 77, Nos. 1-2, p. 46.
1952. *Gahrliepia nanus* (OUDEMANS), Fuller, Zool. Verh., No. 18, pp. 213-214. (Complete redescription.)

Diagnosis of larva.—The only known *Gahrliepia* with the following combination of characters: Coxae 1-setose; palpal formula *N/N/NNN;* with 2 pairs of usurped setae on the scutum. With a suggestion of paired eyes, according to Fuller, but no eyes visible in our specimens. Palpal claw 3-pronged. Palpal femur laterally somewhat angled. Scutum with uniformly scattered micropunctations. Scutum broadest between levels of *PLs* and first pair of usurped setae. *ALs* about as long as *PLs.* Usurped setae marginal. *PPW-1* is 84 microns; *PPW-2,* 65; *PPP-1,* 65; *PPP-2,* 54; sensillae clavate. With 24 dorsal setae arranged 2.2.4.6.4.4.2 (excluding usurped setae), according to Fuller; our specimens with 28 to 30 setae. With about 38 ventral setae; these minutely barbed. Coxa III, ratio of length to breadth, 46:34 microns=1.3. Standard measurements (in microns) of our two specimens (which are virtually identical with those reported by Fuller for one of type series in Oudemans collection):

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Mean	43	74	38	17	92	36	29	22/35	20	1.6	0.67	4.4	1.37
Range	2	2	3	3	1	1	3	...	..	0.07	0.02	0.8	0.02

Type material.—Described from 3 specimens—1 ex the bat *Hipposideros caffer* Sundewall, and 2 ex the rodent *Georhychus hottentottus* Lesson, Durban, South Africa. Type originally deposited in Trägårdh's collection, Stockholm. One of these, ex *Georhychus,* in Oudemans collection, can be regarded as a paratype, fide Fuller.

Records and comments.—Two specimens ex *Thallomys namaguensis* (a rodent), South Africa, Johannesburg, February 5, 1950 (received from Dr. F. Zumpt, through courtesy of Dr. J. R. Audy).

This species, the genotype, is the only one in the subgenus collected from a bat. However, two of the original specimens were from a rodent, as were ours. The specimens from *Thallomys* agree with the published figures and descriptions in all significant respects. How-

ever, Oudemans states that the sternal setae and coxal setae are nude. Fuller verifies this, but points out that he believes the nude condition is apparent, rather than real, and due to trauma. These bristles bear pinnae in our specimens.

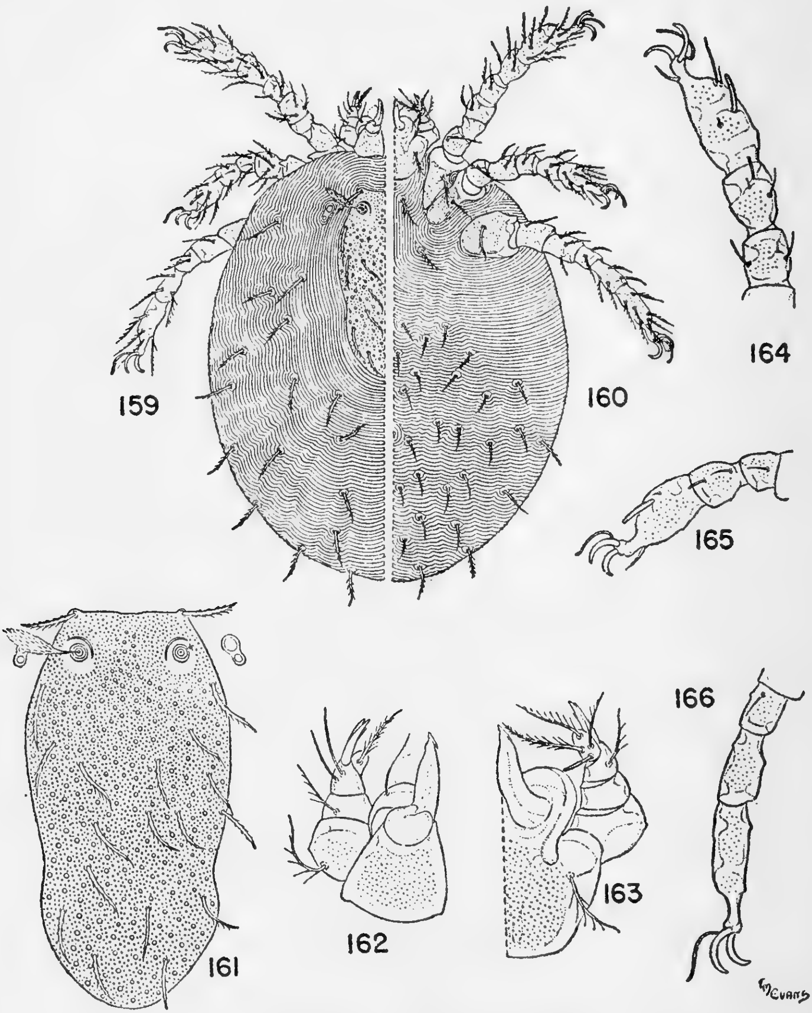
GAHRLIEPIA (GAHRLIEPIA) FLETCHERI Gater, 1932

Figures 159-163

1932. *Gahrliepia fletcheri* GATER, Parasitol., vol. 24, No. 2, pp. 161-163, fig. 9.
1938. *Gateria fletcheri* (GATER), Ewing, Journ. Washington Acad. Sci., vol. 28, No. 6, p. 295.
1942. *Gateria fletcheri* (GATER), Radford, Parasitol., vol. 34, No. 1, p. 67, fig. 48.
1943. *Gahrliepia fletcheri* GATER, Womersley and Heaslip, Trans. Roy. Soc. South Australia, vol. 67, No. 1, pp. 138, 140, pl. 13, fig. 3.
1945. *Gahrliepia fletscheri* (*sic!*) GATER, Buitendijk, Zool. Meded., vol. 24, p. 337 (*lapsus*).
1946. *Gateria spinulosa* RADFORD, Proc. Zool. Soc. London, vol. 116, pt. 2, p. 252, figs. 11, 12. New synonymy.
1947. *Gahrliepia fletcheri* GATER, Audy, Nature, London, vol. 159, pp. 295-296.
1947. *Gateria fletcheri* (GATER), Sig Thor and Willmann, Trombidiidae, Das Tierreich, Lfg. 71b, p. 339, fig. 405.
1948. *Gateria fletcheri* (GATER), Fuller, Bull. Brooklyn Ent. Soc., vol. 43, No. 4, p. 110.
1950. *Gateria fletcheri* (GATER), Radford, Int. Union Biol. Sci. (Paris), ser. C, No. 1, p. 98.
1951. *Gateria fletcheri* (GATER), Wharton et al., Journ. Parasitol., vol. 37, No. 1, p. 27.
1952. *Gahrliepia* (*Gateria*) *fletcheri* GATER, Womersley, Rec. South Australia Mus., vol. 10, Nos. 1-2, pp. 285, 311, pl. 83, figs. F-H.
1952. *Gahrliepia* (*Gateria*) *spinulosa* (RADFORD), Womersley, op. cit., pp. 309-310, pl. 83, fig. E.
1952. *Gateria fletcheri* (GATER), Wharton and Fuller, Mem. Ent. Soc. Washington, No. 4, p. 93.
1952. *Gateria spinulosa* RADFORD, Wharton and Fuller, op. cit., p. 94.
1952. *Gateria fletcheri* (GATER), Gunther, Proc. Linn. Soc. New South Wales, vol. 77, Nos. 1-2, p. 47.
1952. *Gateria spinulosa* RADFORD, Gunther, op. cit., p. 48.
1952. *Gateria spinulosa* RADFORD, Fuller, Zool. Verh., No. 18, p. 217.
1952. *Gateria fletcheri* (GATER), Fuller, op. cit., pp. 216, 218, fig. 7d. (Includes complete description based upon type material.)

Diagnosis of larva.—A nonscrobiculate species which is highly variable regarding standard measurements and chaetotaxy. Palpal formula $B/B/NNb(N)$. Palpal claw 3-pronged. Eyes double. With 10 to 17 (usually 12 or 13, rarely more than 14) usurped setae on scutum; most of these nonmarginal and arranged in 3 or 4 highly irregular rows. First row of usurped setae definitely caudad to line

of *PLs.* Scutum about one and nine-tenths times as long as broad at maximum. With 2 types of pits on scutum: one the size of setal bases, evenly distributed beyond *PLs,* and the second type consisting



FIGS. 159-166.—*Gahrliepia* (*Gahrliepia*) *fletcheri* Gater, 1932.

of scattered minute punctae. With 26 to 32 dorsal setae (excluding usurped setae), often arranged 2.4.4.6.6.4, the rest irregular. About 50 to 60 ventral setae present, including 20 to 26 postanals. The ratio of length to breadth of coxa III is 23 to 20 = 1.15. Coxae 1-setose.

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype *	53	78	48	22	160	42	35	38	35	...	0.43	3.6	...
50 specimens: †													
Mean	48	73	44	21	144	37	32	34	33	72/53=1.34	0.44	3.47	1.4
Range + or −	6	10	7	4	22	6	6	6	5	0.09	0.05	0.3	0.07

* After Fuller, 1952.
† Based upon material from Malaya (including 5 paratypes), Assam, and Burma.

Type material.—Ex *Rattus rattus diardi* (Jentink) (equals *Rattus rattus argentiventer,* partim?—vide Harrison and Audy, 1951), Malaya, Selangor. "Holotype, No. 1932-7-18-22 and paratypes Nos. 1932-7-18-23 and 24 in the British Museum (Natural History); paratypes in the United States National Museum (two specimens, both No. 1056); Molteno Institute, Cambridge, England; King Edward VII College of Medicine, Singapore; and Rijksmuseum van Natuurlijke Historie, Leiden" (Fuller, 1952).

Comment and records.—The measurements for Assam and Burma specimens usually were 3 microns less than the mean cited in the above table. However, such specimens were otherwise indistinguishable from typical Malayan *G. fletcheri,* and occasionally large Assam-Burma individuals and small Malayan ones were noted. All extremes encountered were, therefore, considered merely variants of *G. fletcheri.*

Gater (1932) pointed out that *G. fletcheri* is very variable morphologically, and stated "since the extremes of variation can be found among specimens of the same cluster and in some cases in the same individual, it would be unjustifiable to form more than one species." Some extent of the individual differences encountered by us can be judged by the range cited in the table of standard measurements above. This surprising variability, fully demonstrable only when long series of specimens are available for study, is believed to have led Womersley (1952) and Radford (1946) astray. The differences Womersley cites (p. 310) to separate *G. fletcheri* and *G. spinulosa* do not hold, because even paratype *G. fletcheri* often have the scutal shape and arrangement and number of scutal setae ascribed to Malayan *"spinulosa."* Radford apparently described *G. spinulosa* on the basis of one specimen, and there is nothing in the description or measurements to separate this specimen from *G. fletcheri* as we now know it. Fuller (1952) examined the type of each species but discussed only *G. fletcheri.* In his key to *Gateria* he treats *G. spinulosa* as a valid species, separating it from *G. fletcheri* by virtue of the scutum's bearing only minute punctae instead of the two types found in *G. fletcheri.* An examination of Fuller's manuscript notes reveals

no further distinctions. The absence of the larger pits may indeed prove to be a valid character for establishing *G. spinulosa* as a true species. However, the secondary scutal pits of *G. fletcheri* are often very difficult to see, and at times show up only in freshly mounted specimens. All the Burma specimens, as well as those from Malaya, possessed pits the size of setal pores, in addition to punctae, and hence could not be *G. spinulosa*. (Such pits were always absent in the related *G. darita*, new species, which is also separable on other grounds.) For these reasons *G. spinulosa* is considered a synonym of *G. fletcheri*.

Gater, at the time of the original description, listed the following hosts, all from Selangor during the months March through November, 1929: *Rattus rattus diardi* (=*Rattus rattus argentiventer*, at least in part) at Kuala Lumpur; "*Rattus sabanus vociferans* Miller," "*Sciurus caniceps concolor* Blyth" (=*Callosciurus*), *Tupaia glis ferruginea* and *Rhinosciurus tupaioides laticaudatus* (Blyth) (as *tupaiodes, sic!*) at Sungei Buloh. The U. S. Army Medical Research Unit's records are as follows: In the primary forest of Ulu Langat, 20 miles east of Kuala Lumpur, 14 specimens ex 4 *Rattus sabanus* (Thomas). In the primary forest of Ulu Gombak, 16 miles north of Kuala Lumpur, 24 specimens ex one *Rattus canus malaisia* Kloss, 1 from *Rattus mülleri* (Jentink), and 1 from *Tupaia minor* Gunther. In the scrub terrain of Sungei Way, 8 miles southwest of Kuala Lumpur, 13 ex a single *Rattus exulans concolor* (Blyth) and 2 from *Rattus rattus argentiventer* (Robinson and Kloss). The Colonial Office Medical Research Unit has records as follows: 1 ex *Rattus bowersi* (Anderson) and 3 ex *Tupaia glis* (Diard) at Ulu Langat. *G. fletcheri* was therefore collected on a variety of small mammals in Malaya in both primary forest and secondary vegetation. Both Gater's and our records indicate no seasonal preference, for it was found during rainy months as well as during the short relatively dry spells.

Gahrliepia (*G.*) *fletcheri* was collected by the U. S. A. Typhus Commission in Assam and North Burma on only 63 occasions out of a total of 1,400 mammals and 260 birds examined in the period December 1944 to December 1945. In all, 249 specimens were collected. As a rule *G. fletcheri* constituted from 5 to 20 percent of the chiggers examined in these instances, but rarely as many as 40 to 50 percent of the chiggers on a shrew belonged to this species. The hosts and general locality distribution are listed in table 1.

Approximately one-fourth of the hosts were captured in true primary forest and the remainder in secondary or scrub growth. Almost one-third, i.e., 19, of the mammals carrying *G. fletcheri* were collected in the dry season, but 16 of the hosts were taken during the height

of the rainy season. In summary it may be said that in North Burma and Assam this species was collected relatively infrequently, but only from mammals, and that it exhibited little definite ecological preference as concerns type of terrain or season, and it was taken in all three of the geographical areas studied. Virtually half of the records were from real shrews or tree shrews.

TABLE 1.—*Hosts and general locality distribution of* Gahrliepia (G.) fletcheri

Host	Geographical location		
	Ledo	Shingbwiyang	Myitkyina
"Shrew"	1		1
Crocidura vorax G. M. Allen		2	
Suncus caerulaeus fulvocinereus (Anderson)	14	4	
Tupaia belangeri versurae Thomas	1	2	6
"Rat"			1
Rattus f. fulvescens (Gray)		1	3
Rattus flavipectus yunnanensis (Anderson)	1	4	
Rattus rattus sladeni (Anderson)		14	8
Total number collections	17	27	19

Gater called attention to the reluctance of *G. fletcheri* to leave its host, and stated that it was "the only [chigger] found on some rats which had been dead for twelve hours or more when received." This observation was often repeated in Burma and Malaya. In fact *G. fletcheri* would often stay attached to the ears and legs of rats which had been severed and placed in the refrigerator for 48 to 72 hours.

GAHRLIEPIA (GAHRLIEPIA) CETRATA Gater, 1932

Figures 167-169

1932. *Gahrliepia cetrata* GATER, Parasitol., vol. 24, No. 2, pp. 165-167, fig. 12.
1942. *Gahrliepia cetrata* GATER, Radford, Parasitol., vol. 34, No. 1, p. 64, fig. 35.
1943. *Gahrliepia cetrata* GATER, Womersley and Heaslip, Trans. Roy. Soc. South Australia, vol. 67, No. 1, pp. 138, 140, pl. 13, fig. 1.
1945. *Gahrliepia cetrata* GATER, Buitendijk, Zool. Meded., vol. 24, p. 336.
1947. *Gahrliepia cetrata* GATER, Sig Thor and Willmann, Trombidiidae, Das Tierreich, Lfg. 71b, pp. 333-334, fig. 399.
1948. *Gahrliepia cetrata* GATER, Fuller, Bull. Brooklyn Ent. Soc., vol. 43, No. 4, p. 109.
1952. *Gahrliepia* (*Gahrliepia*) *cetrata* GATER, Womersley, Rec. South Australia Mus., vol. 10, Nos. 1-2, pp. 283, 304, pl. 82, fig. A.
1952. *Gahrliepia cetrata* GATER, Wharton and Fuller, Mem. Ent. Soc. Washington, No. 4, p. 93.
1952. *Gahrliepia cetrata* GATER, Gunther, Proc. Linn. Soc. New South Wales, vol. 77, Nos. 1-2, p. 46.
1952. *Gahrliepia cetrata* GATER, Fuller, Zool. Verh., No. 18, pp. 215-216. (Complete redescription based upon holotype and three paratypes.)

Diagnosis of larva.—A nonscrobiculate species with 2 pairs of submarginal or submedial usurped setae on the scutum. Palpal setal formula *B/N(b)/NNF*. Palpal claw 3-pronged. Two pairs of eyes but these somewhat reduced. *PPL-1* almost midway between *PL* and *PPL-2* but nearer *PLs*. *PPL-2* midway between posterior margin of scutum and *PPL-1*. *PPW-1* is 53 microns (± 3); *PPW-2*, 41 (± 8); *PPP-1*, 109 (± 7); *PPP-2*, 59 (± 4). Scutum about one and nine-tenths times as long as broad at maximum. With two types of pits on scutum: one slightly smaller than setal bases, evenly distributed beyond sensillary bases; and the second type consisting of scattered minute punctae. With about 32 dorsal setae (excluding usurped setae) usually arranged 2.4.4.6.6.4.4.2. With about 50 to 60 ventral abdominal setae, including approximately 20 postanals. Coxae 1-setose. The ratio of length to breadth of coxa III is 1.42.

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype *	51	77	48	24	...	40	32	42	...	...	...	..	...
Others:													
Mean	49	80	47	23	166	39	35	43	39-44	80/58=1.4	0.44	3.5	1.32
Range + or −	4	5	3	2	10	3	3	6	5	0.08	0.05	0.2	0.10

* After Fuller, 1952.

Type material.—Holotype and 12 paratypes ex "*Rattus edwardsi ciliatus* Bonhote," Malaya, Pahang, Fraser's Hill, elevation 4,500 feet. According to Fuller (1952), "Holotype No. 1932-7-18-19 and two paratypes, Nos. 1932-7-18-20 and 21, in British Museum (Natural History). Paratypes . . . also in . . . U. S. National Museum; the Molteno Institute, Cambridge, England; King Edward VII College of Medicine, Singapore; and the Rijksmuseum van Natuurlijke Historie, Leiden."

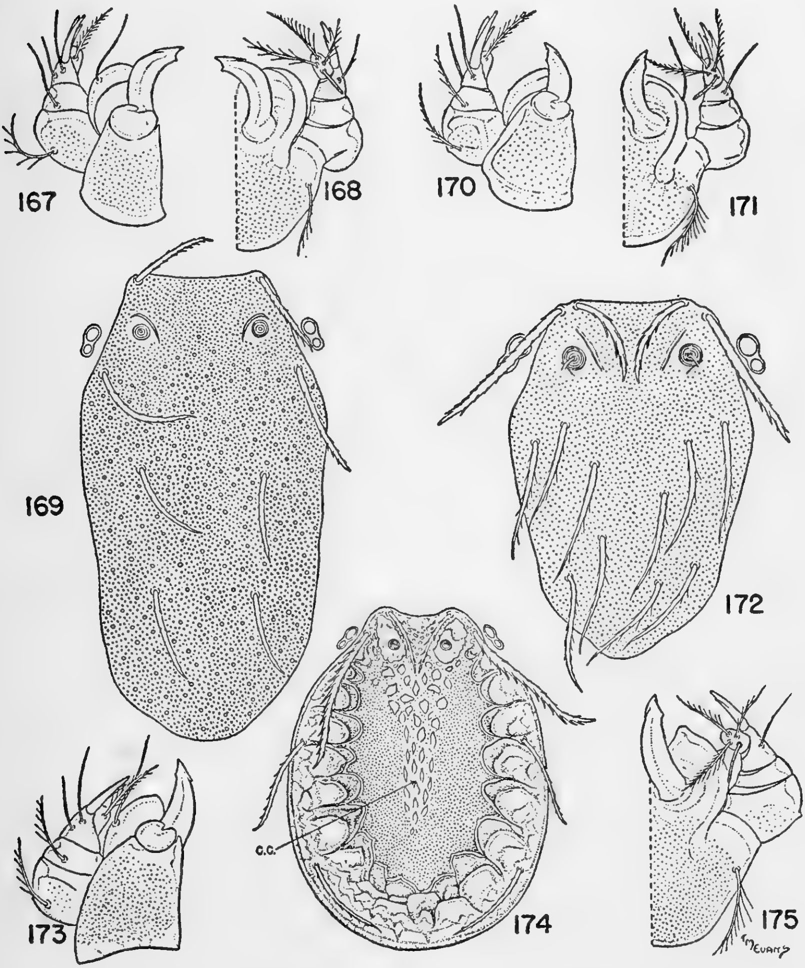
Records and comment.—One specimen ex *Rattus edwardsi*, Malaya, Pahang, Fraser's Hill, elevation 4,500 feet (R. Traub, for U. S. Army Medical Research Unit), January 3, 1950. Five ex *Rattus sabanus*, Malaya, Selangor, Ulu Langat, in primary forest at approximately 2,500 feet elevation; Colonial Office Medical Research Unit, January 15, 1952. One ex *Rattus müllerí*, ibid., but August 5, 1952.

These are the first records since the original description. As can be seen from the records, this species seems to be a characteristic inhabitant of the mountain forests of Malaya. Despite intensive collecting by the Colonial Office Medical Research Unit and the U. S. Army Medical Research Units in the vicinity of Kuala Lumpur, this species has not been encountered in scrub terrain.

GAHRLIEPIA (GAHRLIEPIA) HIRSUTA (Radford, 1946)

Figures 170-172

1946. *Gateria hirsuta* Radford, Proc. Zool. Soc. London, vol. 116, No. 2, pp. 249, 252, figs. 5-6.



Figs. 167-169.—*Gahrliepia* (*Gahrliepia*) *cetrata* Gater, 1932.
Figs. 170-172.—*Gahrliepia* (*Gahrliepia*) *hirsuta* (Radford, 1946).
Figs. 173-175.—*Gahrliepia* (*Gahrliepia*) *ornata* Womersley, 1952.

1947. *Gateria hirsuta* Radford, Lawrence, *in* Audy et al., War Office, Army Medical Directorate 7, appendix 7, p. 5.

1952. *Gahrliepia* (*Gateria*) *hirsuta* (Radford), Womersley, Rec. South Australia Mus., vol. 10, Nos. 1-2, pp. 305, 306, pl. 82, figs. B-D.

1952. *Gateria hirsuta* RADFORD, Wharton and Fuller, Mem. Ent. Soc. Washington, No. 4, p. 94.

1952. *Gateria hirsuta* RADFORD, Gunther, Proc. Linn. Soc. New South Wales, vol. 77, Nos. 1-2, p. 47.

1952. *Gateria hirsuta* RADFORD, Fuller, Zool. Verh., No. 18, p. 217.

Diagnosis of larva.—Characterized by having the *PL* setae displaced anteriorward, so that they are adjacent to *ALs* (thereby agreeing with *G. gemina, G. dupliseta,* and *G. plurisetae,* new species) and having 8 to 10 usurped setae on the scutum. Palpal formula *b/b/NNN*. Palpal claw 3-pronged. Eyes 2+2. Scutum somewhat pentagonal; about one and a half times as long as broad; broadest at about level of first row of usurped setae, caudally almost angulate. Scutum with micropunctae. Usurped setae arranged 4.2.2 or 4.2.2.2. With about 34 dorsal setae (excluding usurped setae) arranged 2.4.4.6.6.4.4.2.2. With about 46 ventral setae, of which true ventrals are about 23 microns in length and postanals 38.

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype *	41	60	46	22	122	11	45	72	38-45	..	0.42	2.7	...
Other (1)†	38	56	44	23	111	9	39	60	35-46	56/103=0.9	0.42	2.5	1.05

* After Fuller in MS.
† Same data as paratype.

Type material.—Holotype ex "*Suncus* (*Crocidura*) *caerulus fulvocinereus* (Anderson)," a shrew. Manipur, Imphal, Kanglatongbi, April 29, 1945, G. H. Q. (India) Field Typhus Research Team. Deposited in British Museum (Natural History). "A second specimen was taken on the type host from the same area on June 21, 1945, and 13 specimens were taken on a mole from the same area on June 22, 1945."

Records and comment.—One specimen examined from Imphal collection through courtesy of J. R. Audy, and presumably the same as that referred to by Womersley (1952) as "No. 61."

GAHRLIEPIA (GAHRLIEPIA) SADUSKI Womersley, 1952

Figures 176-179

1952. *Gahrliepia* (*Gahrliepia*) *saduski* WOMERSLEY, Rec. South Australia Mus., vol. 10, Nos. 1-2, pp. 283, 301-302, pl. 78, figs. H-J. (As *Gateria* on pl. 78.)

1952. *Gahrliepia* sp. JAMESON, KEEGAN, and TOSHIOKA, Parasitic mites found on small mammals in Japan and Korea, Office of the Surgeon, Far East Command (U. S. Army, Tokyo), p. 11, fig. 10C.

1954. *Gahrliepia* (*Gahrliepia*) *saduski* WOMERSLEY, Sasa and Jameson, Proc. California Acad. Sci., ser. 4, vol. 28, No. 5, p. 254, fig. 3.

Diagnosis of larva.—The only species in the subgenus with more than 2 setae on coxa III, i.e., 4 or 5. Palpal setal formula *b(N?)/B/NNB*. Palpal claw 3-pronged. Eyes 2+2. Scutum nonornate, with the usual micropunctae. With 2 to 5 usurped setae on scutum; these often in 2 rows, often including a caudomarginal pair. With about 28 to 32 dorsal setae usually commencing 2.8.8 (excluding usurped setae). With about 36 ventral setae. Coxa III ratio, length to breadth, is 1.51.

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Type series *	49	64	41	22	65	38	36	35	50	...	0.74	2.9	...
Others (6):													
Mean	49	65	42	22	70	38	37	41	35-46	1.21	0.7	3.1	1.26
Range + or −	2	3	3	1	4	3	3	4	...	0.08	0.03	0.4	1.08

* After Womersley, modified.

Type material.—Holotype and 2 paratypes ex *Mus* sp., Japan, Yamagata Prefecture, near Yachi, October 28, 1945 (C. B. Philip). "Four other specimens" ex *Microtus montebelloi* ("embedded in the belly"), Japan, Niigata, October 18, 1945, "and a further specimen from the latter host and locality," January 1946 (T. O. Berge, nec Berga (sic)). Apparently deposited in collections of South Australia Museum, Adelaide.

Records and comment.—Five specimens from Japan as follows: 2 ex *"Apodemus sylvaticus speciosus,"* Honshu, Shiga Prefecture, Hiei-zan, March 27, 1952 (E. W. Jameson, for U. S. Army 406th Medical General Laboratory, Tokyo). One ex *Clethrionomys,* Kyoto, Chara, March 8, 1952 (E. W. Jameson). Two ex *"Apodemus sylvaticus speciosus,"* Honshu, Murayama, December 18, 1952 (406th M. G. L.). Additional records are in the files of the 406th Medical General Laboratory.

GAHRLIEPIA (GAHRLIEPIA) ORNATA Womersley, 1952

Figures 173-175

1952. *Gahrliepia (Gahrliepia) ornata* WOMERSLEY, Rec. South Australia Mus., vol. 10, Nos. 1-2, pp. 283, 304, pl. 81, figs. A-D.

Diagnosis of larva.—With a highly scrobiculate scutum bearing 2 pairs of usurped submarginal setae. Scutum with a medial cluster of ovate scrobiculi about three to four times the diameter of setal bases and with a submarginal row of huge scalloped scrobiculi about three to four times as large as those in the medial patch, the scallops pointing inward, the portion between these scrobiculi densely granuled ex-

cept for region beyond *PLs,* which bears a few ovate pits. *PLs* moved anteriorward, quite close to *ALs* and well anterior to line of *SB*. *PLs* about thrice as long as *ALs* and much stouter. Palpal setal formula *B/B/NNb*. Palpal claw 2-pronged (not clear in holotype). Eyes double; posterior eye almost vestigal. *PPW-1* is about 154 microns; *PPW-2,* 124; *PPP-1,* 139; *PPP-2,* 48; *PPL-1* and *PPL-2,* about 56 microns in length. With about 36 to 44 long, stout, well-ciliated dorsal setae, which in holotype, according to Womersley, are arranged 2.4.8.8.8.8.6 (excluding usurped setae). With 2 rows of 4 setae between coxae III and with about 40 additional ventral setae, of which about 16 are postanals. True ventrals about 20 microns; postanals about 42 microns in length. Coxa III very broad; ratio of length to breadth is 1.07.

STANDARD MEASUREMENTS IN MICRONS

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Holotype *	40	59	34	25	218	12	28	98	60-84	...	0.24	0.24	...
Others:													
Mean	39	67	32	24	211	16	47	106	52-104	63/74=0.92	0.28	0.28	67/64=0.96
Range + or —....	4	8	3	1	10	4	3	6	....	0.08	0.04	0.04	0.06

* After Womersley, modified so as to delete decimals.

Type material.—Unique holotype ex *Rattus sabanus,* Malaya, Selangor, Ulu Langat Forest Reserve, November 18, 1949 (J. R. Audy, for Colonial Office Medical Research Unit).

Records and comment.—Three specimens ex type locality, viz, 1 ex *Rattus sabanus,* September 6, 1951 (R. Traub, for U. S. Army Medical Research Unit); 1 ex *Rattus* sp., July 29, 1950 (J. R. Audy); 1 ex *Rattus mülleri,* September 4, 1951 (J. R. Audy).

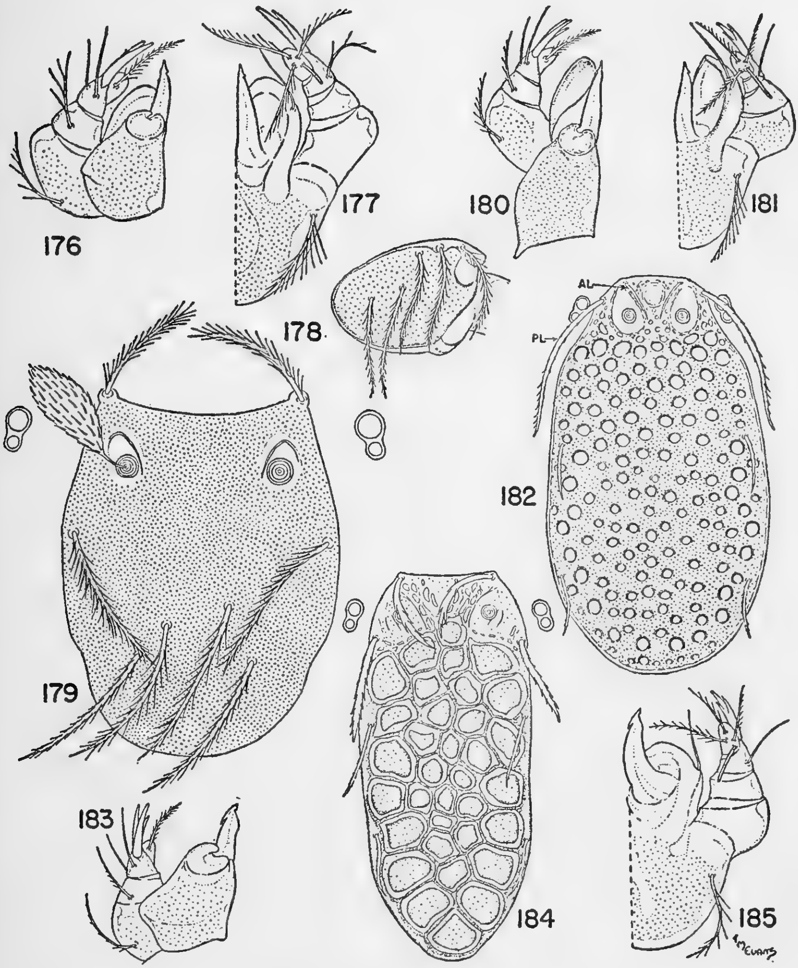
GAHRLIEPIA (GAHRLIEPIA) DECORA Womersley, 1952

Figures 180-182

1952. *Gahrliepia (Gahrliepia) decora* WOMERSLEY, Rec. South Australia Mus., vol. 10, Nos. 1-2, pp. 283, 303-304, pl. 80, figs. A-D.

Diagnosis of larva.—A scrobiculate species with 4 submarginal usurped setae, and in which the scrobiculi on the scutum are subovate pits three to four times the diameter of the setal bases and are evenly distributed posterior to *SB*. Scrobiculi usually separated from one another by a distance equivalent to about three to four times their diameters. Scutum broadly tongue-shaped. *PLs* moved forward to near *ALs* so that they are in a line slightly anterior to *SB;* more than thrice as long as *ALs* and also much stouter, heavily pinnatifid. *PPW-1* and *PPW-2* both 121 microns. *PPP-1* is 134 microns;

PPP-2, 58. Palpal formula: *b/b/NNb(?)*. Palpal claw stated to be 3-pronged. Dorsal setae about 28 to 34 in number, in original description stated to be arranged 2.6.6.6.4.4.2.2.2 (excluding usurped



FIGS. 176-179.—*Gahrliepia (Gahrliepia) saduski* Womersley, 1952.
FIGS. 180-182.—*Gahrliepia (Gahrliepia) decora* Womersley, 1952.
FIGS. 183-185.—*Gahrliepia (Gahrliepia) insigne* Womersley, 1952.

setae). With about 56 ventral setae, of which approximately 17 are postanals. True ventrals about 15 microns in length; postanals 30 microns. Coxae 1-setose. Coxa III very broad; ratio of length to breadth, 1.12.

STANDARD MEASUREMENTS IN MICRONS

	AW	PW	SB	ASB	PSB	A-P	AL	PL	D.S.	PW/Coxa II	PW/SD	PW/ASB	PW/Tarsus III
Type series *	42	67	31	22	240	17	27	108	36-92	...	...	...	...
Range *	3	3	0	0	17	3	2	5	....	...	...	...	...
Other (1)	40	60	27	23	223	14	27	98	46-81	60/81=0.74	0.24	2.61	60/70=0.86

* After Womersley, modified so as to delete decimals.

Type material.—Holotype and 6 paratypes from ex *Rattus sabanus,* Malaya, Selangor, Ulu Gombak Forest Reserve, 16 miles north of Kuala Lumpur, November 15, 1948 (J. R. Audy, for Colonial Office Medical Research Unit). Apparently deposited in collections of South Australia Museum, Adelaide.

Records and comment.—One ex *Rattus sabanus,* Malaya, Selangor, Kepong, April 11, 1950 (C.O.M.R.U.). All records are from the primary jungle. This species has not been taken in scrub terrain despite intensive collecting by both the U. S. Army and Colonial Office Medical Research Units in the vicinity of Kuala Lumpur.

GAHRLIEPIA (GAHRLIEPIA) INSIGNE Womersley, 1952

Figures 183-185

1952. *Gahrliepia (Gahrliepia) insigne* WOMERSLEY, Rec. South Australia Mus., vol. 10, Nos. 1-2, pp. 283, 302-303, pl. 79, figs. A-D.

Diagnosis of larva.—A species with a highly scrobiculate scutum and 2 pairs of submarginal usurped setae. Scutum with about 30 very large subquadrate or polygonal scrobiculi, covering most of scutum posterior to *PLs.* The pits about five or more times diameter of the setal bases. Scutum about twice as long as broad at maximum; broadly tongue-shaped. Sensillary bases' level almost midway between *ALs* and *PLs.* Palpal setal formula *b/b/NNN.* Palpal claw apparently 3-pronged (appeared 2-pronged in unique holotype). Eyes 2+2. *PPW-1* about 77 microns; *PPW-2,* 74; *PPP-1,* 118; *PPP-2,* 64. With about 32 stoutly ciliated dorsal setae arranged 2.6.6.6.6.4.2 (excluding usurped setae). With about 56 ventral setae. True ventrals about 30 microns; postanals 40 microns. Coxa III in ratio of 1.33.

STANDARD MEASUREMENTS IN MICRONS

	AW	PW	SB	ASB	PSB	A-P	AL	PL	D.S.	PW/Coxa II	PW/SD	PW/ASB	PW/Tarsus III
Holotype *	45	76	45	22	174	31	40	53	....	...	0.39	3.45	...
Others (3):													
Mean	41	68	40	19	168	29	39	52	....	68/59=1.16	0.36	3.48	68/81=1.19
Range + or −	2	2	2	2	14	2	2	4	37-46	0.06	0.04	0.06	0.04

* After Womersley, 1952, modified so as to delete decimals.

Type material.—Unique holotype ex *Tupaia glis,* a tree shrew, Malaya, Selangor, Ulu Gombak Forest Reserve, Pahang Road (about 16 miles north of Kuala Lumpur—authors), August 18, 1948 (J. R. Audy, for Colonial Office Medical Research Unit). Deposited in collections of South Australia Museum, Adelaide.

Records and comments.—The three specimens examined by us are the first records since the original description and were also collected by J. R. Audy about 10 miles from the type locality, at Ulu Langat Forest Reserve. Two ex *Rattus bowersi,* October 14, 1951; one ex *Rattus sabanus,* September 6, 1951. All agree closely with Womersley's figures and description.

GAHRLIEPIA (GAHRLIEPIA) PHILIPI (Jadin and Vercammen-Grandjean, 1952)

Figure 186

1952. *Gateria philipi* (JADIN AND VERCAMMEN-GRANDJEAN), Ann. Soc. Belge Med. Trop., vol. 33, 629-630; pl. 10, figs. A-F; pl. 17, fig. H; pl. 19, fig. H.

Diagnosis of larva.—Palpal formula, *N/N/NNN.* Coxal setal formula, 1-1-2. *Scutum:* Nonornate; with one kind of punctae; with 6 usurped setae, of which *PPL-2* are displaced somewhat mesad and lie almost midway between the marginal *PPL-1* and *PPL-3.* Eyes apparently absent. With 30 dorsal setae (excluding those on scutum) arranged 2.2.4.6.6.4.4.2, with about 56 ventral setae.

STANDARD MEASUREMENTS IN MICRONS

AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*
41	71	43	23	101	38	34	18	42	...	0.57	3.09

Type material.—Ex *Dasymys bentleyae* Thomas, Belgian Congo: Ruanda, Astrida, April 30, 1952. Holotype deposited in Museum of Belgian Congo at Tervuren (only specimen known).

Comment.—The remarks made for *G. lawrencei* also apply here.

GAHRLIEPIA (GAHRLIEPIA) LAWRENCEI Jadin and Vercammen-Grandjean, 1952

Figure 187

1952. *Gahrliepia lawrencei* JADIN AND VERCAMMEN-GRANDJEAN, Ann. Soc. Belge Med. Trop., vol. 33, No. 6, pp. 625-627, pl. 9, fig. A-E; pl. 17, fig. G; pl. 19, fig. G.

Diagnosis of larva.—Palpal formula *N/N/NNN*. Coxal setal formula, 1-1-2. *Scutum:* Nonornate; with one kind of punctae; with 4 usurped setae, which are submarginal and first two of which are in line with angles of scutum. Eyes apparently absent. With 28 dorsal setae (excluding those on scutum) and 46 ventral setae. This species is well described and fully illustrated in detail in the original description.

STANDARD MEASUREMENTS IN MICRONS

AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PPW-1*	*PPW-2*
38	22*	37	20	95	34	21	15	28	...	0.19	1.1	71	48

* Sic! Apparently a *lapsus*, for *PW* is obviously greater than *AW*.

Type material.—Ex *Dasymys bentleyae* Thomas, Belgian Congo: Ruanda, Astrida, March 28, 1952. Holotype deposited in museum of Belgian Congo at Tervuren (only specimen known).

Record and comment.—The above data and diagnosis are from Jadin and Vercammen-Grandjean, but modified in accordance with terminology employed herein. Thus, what Jadin and Vercammen-Grandjean (1952) call the "mediolateral setae" are referred to as *PLs* by us, whereas our *PPL-1* are designated the posterolaterals by Jadin and Vercammen-Grandjean because they are at the maximum width of the scutum.

GAHRLIEPIA (GAHRLIEPIA) CILIATA Gater, 1932

Figure 188

1932. *Gahrliepia ciliata* Gater, Parasitol., vol. 24, No. 2, pp. 163-164, fig. 10.
1938. *Gateria ciliata* (Gater), Ewing, Journ. Washington Acad. Sci., vol. 28, No. 6, p. 295.
1940. *Gahrliepia ciliata* Gater, Gunther, Proc. Linn. Soc. New South Wales, vol. 65, Nos. 5-6, p. 481.
1942. *Gateria ciliata* (Gater), Radford, Parasitol., vol. 34, No. 1, p. 67, fig. 49.
1943. *Gahrliepia ciliata* Gater, Womersley and Heaslip, Trans. Roy. Soc. South Australia, vol. 67, No. 1, p. 140, pl. 13, fig. 2.
1947. *Gateria ciliata* (Gater), Sig Thor and Willmann, Trombidiidae, Das Tierreich, Lfg. 71b, pp. 339-340, fig. 406.
1948. *Gateria ciliata* (Gater), Fuller, Bull. Brooklyn Ent. Soc., vol. 43, No. 4, p. 110.
1952. *Gahrliepia* (*Gateria*) *ciliata* Gater, Womersley, Rec. South Australia Mus., vol. 10, Nos. 1-2, p. 309, pl. 83, fig. D.
1952. *Gateria ciliata* (Gater), Wharton and Fuller, Mem. Ent. Soc. Washington, No. 4, p. 93.
1952. *Gateria* (?) *ciliata* (Gater), Gunther, Proc. Linn. Soc. New South Wales, vol. 77, Nos. 1-2, p. 47.
1952. *Gateria ciliata* (Gater), Fuller, Zool. Verh., No. 18, p. 217.

Diagnosis of larva.—Apparently near *G. fletcheri* Gater but with only 2 usurped setae submedial and 8 submarginal, instead of most being submedial, and with first 2 palpal setae nude, not barbed. Palpal

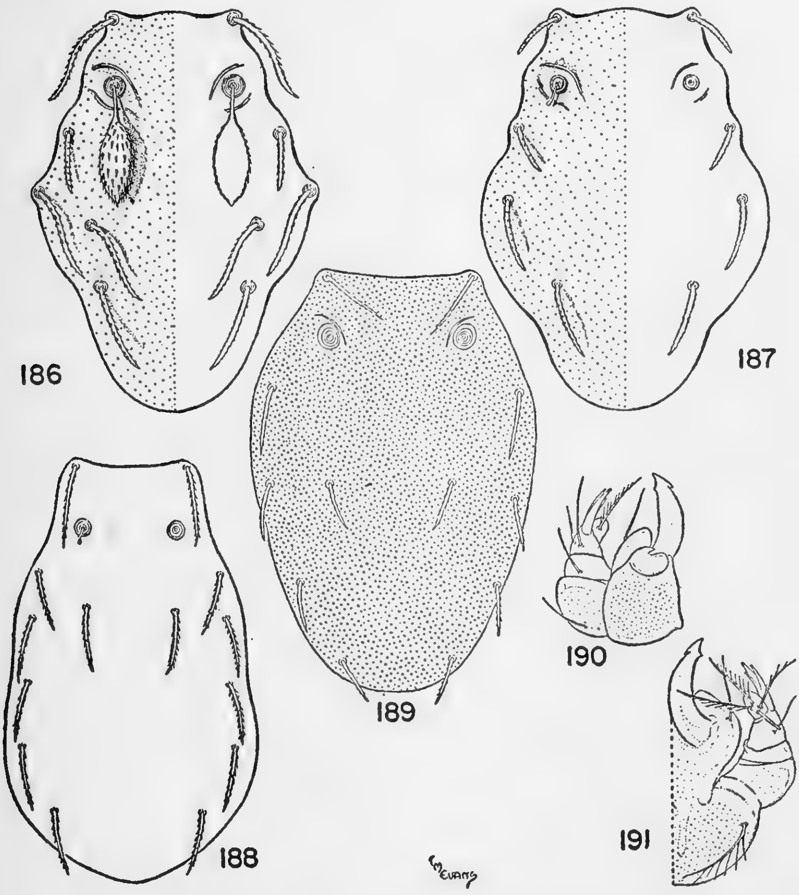


FIG. 186.—*Gahrliepia (Gahrliepia) philipi* (Jadin and Vercammen-Grandjean, 1952).
FIG. 187.—*Gahrliepia (Gahrliepia) lawrencei* Jadin and Vercammen-Grandjean, 1952.
FIG. 188.—*Gahrliepia (Gahrliepia) ciliata*, Gater, 1932.
FIGS. 189-191.—*Gahrliepia (Gahrliepia) rutila* Gater, 1932.

formula, *N/N/NNN*. Palpal claw 3-pronged. Eyes 2+2. Scutum uniformly micropunctate; very large; broadly tongue-shaped but with lateral margins slightly sinuate; broadest at about one-fourth from posterior end. With 4 pairs of submarginal usurped setae and a medial pair inserted near anterior third. *SB* about midway between

ALs and *PLs*. Sensillae missing. *ALs* and *PLs* coarsely pilose, more so than are usurped setae. Dorsal setae long, stout, "coarsely pilose, almost pectinate" arranged 2.4.4.4.6.4.2.4.2. Coxae 1-setose.

STANDARD MEASUREMENTS OF HOLOTYPE * IN MICRONS

AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	$\frac{PW}{SD}$	$\frac{PW}{ASB}$
47	71	39	25	163	45	42	39	0.37	2.8

* After unpublished notes of J. R. Audy.

Type material.—Holotype ex the ear of *Rattus mülleri validus* (Miller), Malaya, Selangor, Sungei Buloh. Deposited in British Museum (Natural History).

Comment.—This species is known only from the type and has not been seen by us.

GAHRLIEPIA (GAHRLIEPIA) RUTILA Gater, 1932

Figures 189-191

1932. *Gahrliepia rutila* GATER, Parasitol., vol. 24, No. 2, p. 165, fig. 11.
1938. *Gateria rutila* (GATER), Ewing, Journ. Washington Acad. Sci., vol. 28, No. 6, p. 295.
1940. *Gahrliepia rutila* GATER, Gunther, Proc. Linn. Soc. New South Wales, vol. 65, Nos. 5-6, p. 481.
1942. *Gateria rutila* (GATER), Radford, Parasitol., vol. 34, No. 1, p. 67, fig. 50.
1943. *Gahrliepia rutila* GATER, Womersley and Heaslip, Trans. Roy. Soc. South Australia, vol. 67, No. 1, p. 138, pl. 12, fig. 8.
1947. *Gateria rutila* (GATER), Sig Thor and Willmann, Trombidiidae, Das Tierreich, Lfg. 71b, pp. 339, 340, fig. 407.
1948. *Gateria rutila* (GATER), Fuller, Bull. Brooklyn Ent. Soc., vol. 43, No. 4, p. 110.
1952. *Gahrliepia (Gateria) rutila* GATER, Womersley, Rec. South Australia Mus., vol. 10, Nos. 1-2, pp. 308-309, pl. 83, figs. A-C.
1952. *Gateria rutila* (GATER), Wharton and Fuller, Mem. Ent. Soc. Washington, No. 4, p. 94.
1952. *Gateria* (?) *rutila* (GATER), Gunther, Proc. Linn. Soc. New South Wales, vol. 77, Nos. 1-2, p. 47.
1952. *Gateria rutila* (GATER), Fuller, Zool. Verh., No. 18, p. 217.

Diagnosis of larva.—Characterized by having 8 usurped setae on the scutum; of these 3 pairs are submarginal and 1 pair submedial near horizontal midline of scutum. Palpal formula apparently *N/N/NNN*. Palpal claw 3-pronged. Eyes double. Scutum with micropunctations, broadly tongue-shaped; broadest slightly beyond *PLs*, posterior margin broadly rounded. Both *AL* and *PL* setae short, subequal. Sensillae bases slightly nearer *ALs* than *PLs;* sensillae unknown. With 24 to 26 dorsal setae; usually arranged 2.2.2.6.4.4.4.2 (excluding

usurped setae). With about 32 to 35 ventral setae, of which 12 to 14 are postanals. True ventrals about 12 microns in length.

STANDARD MEASUREMENTS IN MICRONS OF FIVE TOPOTYPES AND ONE COTYPE

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
Mean	42	70	37	19	97	35	17	17	12/23	70/48=1.48	0.6	3.7	70/44=1.58
Range + or −	1	3	2	1	4	1	1	2	...	0.05	0.04	0.05	0.06

Type material.—Holotype and 6 paratypes ex *Rattus mülleri validus* (Miller), Malaya, Selangor, Sungei Buloh, August 8, 1930. "Two specimens from *Rattus edwardsi ciliatus* (Bonhote) taken at Fraser's Hill, 4,500 feet, Pahang (A. K. Cosgrave), April 25, 1930, are larger (length 0.43 mm.; breadth 0.34 mm.) and have the scutal and body setae longer, but otherwise indistinguishable" (Gater, 1932). Holotype and paratype in British Museum; paratypes in U. S. National Museum; Moltens Institute, Cambridge; and King Edward VII College of Medicine, Singapore.

Records and comment.—Five topotypes ex *Tupaia glis* (C.O.M. R.U.) November 20, 1951. One specimen of the types series, collected by Dr. Cosgrave, examined through the courtesy of Dr. J. R. Audy, bears the designation of "cotype." This species is probably a denizen of the primary forest, as suggested by the known host and locality records and its absence in the well-studied scrub terrain.

GAHRLIEPIA (GAHRLIEPIA) CROCIDURA (Radford, 1946)

Figure 192

1946. *Gateria crocidura* Radford, Proc. Zool. Soc. London, vol. 116, No. 2, p. 252, figs. 7, 8.
1946. *Gateria lancearia* Radford, Proc. Zool. Soc. London, vol. 116, No. 2, p. 256, figs. 13, 14. (New synonymy.)
1947. *Gateria crocidura* Radford, Lawrence, *in* Audy et al., War Office, Army Medical Directorate 7, appendix 7, p. 5.
1947. *Gateria lancearia* Radford, Lawrence, *in* Audy et al., ibid.
1952. *Gahrliepia* (*Gateria*) *crocidura* (Radford), Womersley, Rec. South Australia Mus., vol. 10, Nos. 1-2, p. 307, pl. 82, fig. G.
1952. *Gahrliepia* (*Gateria*) *lancearia* (Radford), Womersley, op. cit., pp. 284, 306-307, pl. 82, fig. F (not E. *lapsus*).
1952. *Gateria crocidura* Radford, Gunther, Proc. Linn. Soc. New South Wales, vol. 77, Nos. 1-2, p. 47.
1952. *Gateria lancearia* Radford, Gunther, op. cit., p. 48.
1952. *Gateria crocidura* Radford, Wharton and Fuller, Mem. Ent. Soc. Washington, No. 4, p. 93.
1952. *Gateria lancearia* Radford, Wharton and Fuller, op. cit., p. 94.
1952. *Gateria crocidura* Radford, Fuller, Zool. Verh., No. 18, pp. 217-218.
1952. *Gateria lancearia* Radford, Fuller, ibid.

Diagnosis of larva.—A nonscrobiculate species with 6 usurped setae on the scutum. Palpal setal formula *B/B/BNb*. Palpal claw 3-pronged. Scutum somewhat pentagonal in shape by virtue of being angled at level of *PL*. Sensillary bases with anteromedial ridges; inserted almost midway between *AL* and *PL*. Scutum with uniform micropunctations. With 38 dorsal setae arranged 2.4.6.6.8.8.4. With approximately 62 ventral setae, of which the true ventrals are 30 to 32 microns in length; postanals 60 microns.

STANDARD MEASUREMENTS OF HOLOTYPE IN MICRONS

AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*
51	92	49	30	120	38	45	60	42-58

Type material.—Holotype ex a shrew, *Suncus caerulus fulvocinereus* (Anderson), India, Manipur, Imphal, March 8, 1945,[11] G. H. Q. (India) Field Typhus Research Team. Deposited in the British Museum (Natural History) (B.M.N.H. No. 1948-2-3-16). Lawrence (1947) adds "Kanglatongbi" to the locality data, and states "appeared in brief period only, not recorded since July 1945. Not common," indicating that more specimens may be extant.

Comment.—*G. lancearia* was described from a single specimen ex a mole, *Talpa micrura* Hodgson, from the type locality of *G. crocidura,* and, like the latter, was collected by the Field Typhus Research Team. *G. lancearia* was considered to be distinctive by virtue of a "lanceolate" sensilla, present only on one side. It is otherwise morphologically indistinguishable from *G. crocidura,* as indicated by the original descriptions and by the unpublished studies of Audy and of Fuller. Careful study by Audy indicates that Radford was understandably misled by an artifact—the sensilla is collapsed on the medial side and its short basal stem is twisted back. *G. lancearia* is hence considered a synonym of *G. crocidura.*

The above description, as well as those which follow, is based upon the literature and upon manuscript notes and drawings prepared by Dr. H. S. Fuller and Dr. J. R. Audy while independently studying the types of the *Gahrliepia* species described by Radford in 1946.

GAHRLIEPIA (GAHRLIEPIA) LONGIPILI (Radford, 1946)

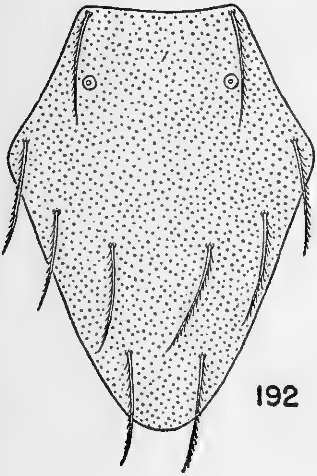
Figure 193

1946. *Gateria longipili* RADFORD, Proc. Zool. Soc. London, vol. 116, No. 2, p. 252, figs. 9-10.

[11] Radford cites the month as May, but Audy, in litt., notes the month as March.

1947. *Gateria longipili* RADFORD, Lawrence, *in* Audy et al., War Office Army Medical Directorate 7, appendix 7, p. 5.

1952. *Gahrliepia* (*Gateria*) *longipilis* (*sic!*) (RADFORD, 1946), Womersley, Rec. South Australia Mus., vol. 10, Nos. 1-2, p. 307, pl. 82, fig. E (not F, *lapsus.*)



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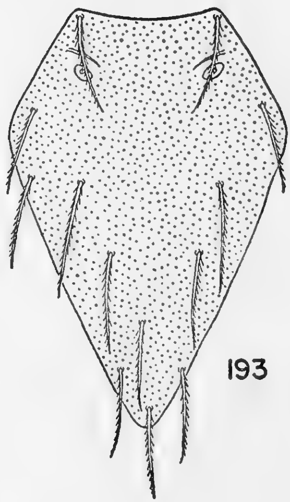

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FIG. 192.—*Gahrliepia* (*Gahrliepia*) *crocidura* (Radford, 1946).
FIG. 193.—*Gahrliepia* (*Gahrliepia*) *longipili* (Radford, 1946).
FIG. 194.—*Gahrliepia* (*Gahrliepia*) *romeri* Womersley, 1952.

1952. *Gateria longipili* RADFORD, Wharton and Fuller, Mem. Ent. Soc. Washington, No. 4, p. 94.

1952. *Gateria longipili* RADFORD, Gunther, Proc. Linn. Soc. New South Wales, vol. 77, Nos. 1-2, p. 48.

1952. *Gateria longipili* RADFORD, Fuller, Zool. Verh., No. 18, p. 217.

Diagnosis of larva.—Close to *G. crocidura* (Radford, 1946) but separable in that there are 9 usurped setae on the scutum, not 6. Resembles *G. crocidura* regarding measurements, but scutum stated to be even more pentagonal than in *G. lancearia* (Radford, 1946), which we deem a synonym of *G. crocidura,* almost pointed posteriorly. Palpal formula, *B/B/BNB.* Palpal claw 3-pronged, according to Fuller (in MS.). Scutum strongly punctate. First 3 usurped setae in a horizontal line; remainder not symmetrically arranged, scattered over posterior half of scutum. Sensillae missing in only specimen extant. Dorsal setae 38 in number; arranged 2.6.6.8.6.2.6.2 (excluding usurped setae). With about 66 ventral setae; true ventrals about 29 microns in length; postanals about 60 microns. Coxae 1-setose.

STANDARD MEASUREMENTS OF HOLOTYPE IN MICRONS *

AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*D.S.*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
51	85	51	26	116†	34	46	57	48-54	...	0.6	3.3	...

* After Radford.
† Fuller (in MS.) cites this as 85.5 in the type and must have used this figure in preparing his published key (1952) for separating *G. longipili* from *G. crocidura.*

Type material.—Holotype ex a shrew, *Suncus caerulus fulvocinereus* (Anderson) (as *Suncus* (*Crocidura*)), Manipur, Imphal, May 8, 1945, collected G. H. Q. India Field Typhus Unit. Deposited in British Museum (Natural History). No other specimen known.

GAHRLIEPIA (GAHRLIEPIA) ROMERI Womersley, 1952

Figure 194

1952. *Gahrliepia* (*Gateria*) *romeri* WOMERSLEY, Rec. South Australia Mus., vol. 10, Nos. 1-2, pp. 284, 308, pl. 83, fig. I.

Diagnosis of larva.—Womersley states that "this species is very near to, and may only be a variant of *G. crocidura* Radford. It appears to differ, however, in the standard data, particularly the larger *PSB* and *A-P,* the position of *SB,* and in the smaller number of dorsal setae." Eyes 2+2, small. Palpal setal formula, *N/N/NNb.* Palpal claw described as 2-pronged. Scutum nonornate, "finely punctate . . . strongly produced behind line of *PL* and taking in 6 extra setae of the second and third dorsal rows; *SB* wide apart and about midway between *AL* and *PL.*" With 36 dorsal setae arranged 2.8.6.6.6.4.2.2 (excluding usurped setae); from 36 to 42 microns long (the shorter ones posteriormost). With about 54 ventral setae; true ventrals apparently 22 microns in length; postanals 36 microns.

STANDARD MEASUREMENTS OF HOLOTYPE IN MICRONS *

AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AL*	*PL*	*PW*/Coxa II	*PW*/*SD*	*PW*/*ASB*	*PW*/Tarsus III
50	86	50	28	157	50	39	42	...	0.47	3.1	...

* After Womersley, modified.

Type material.—Holotype ex *Rattus rattus,* Hong Kong, 1950 (J. D. Romer). Deposited in collections of South Australia Museum, Adelaide. No other specimen known.

Comment.—This specimen is known to us only through the original description.

KEY FOR THE IDENTIFICATION OF THE LARVAE OF THE SUBGENUS *GAHRLIEPIA*

1 Scutum scrobiculate ("ornate"), i.e., bearing large pits, many of which are at least twice the diameter of the setal bases (often much larger), in addition to the usual micropunctae (figs. 86 and 110) 2

Scutum not scrobiculate, often bearing only micropunctae (fig. 5) but also at times with secondary punctae no larger than setal bases (fig. 15) 12

2(1) With 2 setae on coxa III (fig. 134); intersensillary crater present (fig. 129, *I.C.*) 3

With only 1 seta on coxa III (fig. 85); lacking an intersensillary crater (fig. 145) 4

3(2) Lateral margins of scutum mildly sinuate, lacking scallops (fig. 136); scrobiculi smoothly ovate .... *penetrans,* n. sp. (p. 45)

Lateral margins of scutum definitely scalloped (fig. 129); scrobiculi with crenulate margins .... *ampullata,* n. sp. (p. 43)

4(2) *PW* is 90 microns or greater; with 4 usurped[12] setae, which are median in position (fig. 110) 5

PW 70 microns or less; either with more than 4 usurped setae (fig. 94) or with 4, but these are marginal in position (fig. 102) 7

5(4) With base of chelicera posterolaterally produced into a distinct, broad dorsal flap (fig. 111, *FL*); *ALs* and *PLs* very long, over 110 microns in length; *PLs* reaching far beyond bases of first usurped setae (*PPL-1*) (fig. 110); coxa III about $1\frac{1}{2}$ times as long as broad (fig. 109). *laciniata,* n. sp. (p. 37)

With base of chelicera only slightly produced posterolaterally, caudolateral angle acuminate (figs. 146 and 119); *ALs* and *PLs* much shorter, less than 67 microns; *PLs* not extending as far as *PPL-1;* coxa III virtually as broad as long (fig. 121) 6

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[12] Usurped setae are those dorsal setae which arise from the dorsal plate by virtue of its posterior prolongation, i.e., all setae on the scutum except *ALs* and *PLs.*

6(5) Scutum ovate and evenly convex (fig. 145); scutum very long, *PSB* more than $6\frac{1}{2}$ times *AW*..........*granulata*, n. sp. (p. 50)
Scutum somewhat constricted at anterior fourth (fig. 118); *PSB* only about 5 times *AW*..............*tuberculata*, n. sp. (p. 40)

7(4) Marginal scrobiculi on scutum relatively large, size of each equal to about one-fourth to one-third width of scutum (fig. 174) 8
Marginal scrobiculi on scutum much smaller, only about size of sensillary bases..9

8(7) *PLs* displaced anteriorward, so that bases of *PLs* are anterior to line of *SB* (fig. 174); marginal scrobiculi scalloped, pointing inward, and more than 8 times diameter of median pits......................*ornata* Womersley, 1952 (p. 63)
PLs well beyond line of *SB* (fig. 184); marginal scrobiculi only about 2 or 3 times diameter of median ones. *insigne* Womersley, 1952 (p. 66)

9(7) With 4 usurped setae on scutum; *PLs* at least $1\frac{1}{2}$ times length of *ALs* (fig. 102).......................................10
With 8 or more usurped setae on scutum; *PLs* scarcely longer than *ALs* (fig. 94).......................................11

10(9) Scutum with a central core of small trigonal scrobiculi (fig. 102, *C.C.*); submarginal scrobiculi definitely larger than those of core; coxa III slightly broader than long (fig. 101) ....*tessellata*, n. sp. (p. 34)
Scutum lacking a central core; median scrobiculi similar to others on scutum (fig. 182); coxa III somewhat longer than broad........................*decora* Womersley, 1952 (p. 64)

11(9) With 8 usurped setae on scutum (fig. 94)............*picta*, n. sp. (p. 31)
With 17 to 20 usurped setae on scutum (fig. 86)....*evansi*, n. sp. (p. 30)

12(1) Posterolateral setae (*PLs*) moved far anteriorward, adjacent to anterolaterals (*ALs*) so that there appear to be two pairs of *ALs* (fig. 61); *PLs* separated from *ALs* by a distance not greater than the diameter of sensillae bases 13
Posterolateral setae separated from *ALs* by a distance at least thrice the diameter of sensillae bases (fig. 5)................16

13(12) With 8 or 10 usurped setae on the scutum (fig. 172); scutum caudally angled; with all palpal tibial setae nude (figs. 170, 171)....................*hirsuta* (Radford, 1946) (p. 61)
With 4 or 6 usurped setae on the scutum (figs. 70 and 78); scutum caudally rounded; with at least one barbed seta on palpal tibia (fig. 63).......................................14

14(13) With 6 usurped setae; first pair of usurped setae (*PPL-1*) submarginal (fig. 78)......................*plurisetae*, n. sp. (p. 28)
With 4 usurped setae; *PPL-1* not necessarily marginal in position 15

15(14) Usurped setae all submedian (fig. 70); *PSB*:*SB* ratio = 3:1 ....*dupliseta*, n. sp. (p. 26)
Usurped setae marginal (fig. 61); *PSB*:*SB* ratio = 2:1. *gemina*, n. sp. (p. 23)

16(12) With 4 to 5 setae on coxa III (fig. 178).
saduski Womersley, 1952 (p. 62)
With 1 or 2 setae on coxa III....................................17

17(16) With 2 setae on coxa III; anterior portion of lateral margins of scutum markedly sinuate (figs. 186, 187)....................18
With only 1 seta on coxa III; anterior portion of lateral margins of scutum evenly curved or mildly sinuate (figs. 5, 188) 19

18(17) With 6 usurped setae on scutum, including a submedian pair (fig. 186)...*philipi* (Jadin and Vercammen-Grandjean, 1952) (p. 67)
With only 4 usurped setae, all submarginal (fig. 187).
lawrencei Jadin and Vercammen-Grandjean, 1952 (p. 67)

19(17) With only 4 usurped setae on scutum..............................20
With 6 or more usurped setae....................................25

20(19) *PSB* greater than 160 microns; ratio $\frac{PW}{SD}$ approximately 0.42 ....*cetrata* Gater, 1932 (p. 59)
PSB less than 131 microns; ratio $\frac{PW}{SD}$ usually greater than 0.50 21

21(20) *PL* over 60 microns; ventral palpal tibial seta definitely barbed (fig. 4)..22
PL less than 45 microns; ventral palpal tibial seta nude or at most frayed (fig. 168)..23

22(21) *ALs* less than 48 microns in length; scutum with 2 types of punctae[13] (i.e., with pits the size of setal bases in addition to micropunctae) (fig. 15); *PLs* much closer to *ALs* than to *PPL-1*............................*fimbriata*, n. sp. (p. 10)
ALs more than 62 microns in length; scutum with only micropunctae (fig. 5); *PLs* midway between *ALs* and *PPL-1*.................................*exilis*, n. sp. (p. 6)

23(21) All four usurped setae marginal (fig. 153); palpal formula *N/N/NNN*; *PSB* less than 95 microns.
nanus (Oudemans, 1910) (p. 52)
With at least one pair of usurped setae submedian or submarginal; with at least palpal femoral and/or genual bristle somewhat barbed; *PSB* more than 105 microns...........24

24(23) Posterior margin of scutum subtruncate (fig. 45); with fewer than 34 dorsal setae (fig. 43); coxa III only slightly longer than broad (ratio 1.15)..........*elbeli*, n. sp. (p. 18)
Posterior margin of scutum evenly but shallowly convex (fig. 53); with more than 40 dorsal setae (fig. 51); coxa III more than 1.5 times as long as broad.......*tylana*,[14] n. sp. (p. 21)

25(19) With 10 or more usurped setae on scutum...........................26
With 6 to 9 usurped setae......................................28

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[13] This character is best seen in freshly mounted specimens or when examined under oil.

[14] *G. tylana* has from 4 to 9 usurped setae (usually 6) and hence appears again farther down in the key.

26(25) With only 10 usurped setae, of which one pair is median (fig. 188); palpal femoral and genual setae nude. *ciliata* Gater, 1932 (p. 68)

Usually with more than 10 usurped setae (rarely with 10 in *G. fletcheri*); of these at least 3 pairs median; palpal femoral and genual setae barbed (figs. 22 and 162)................27

27(26) With two types of punctae on the scutum—i.e., micropunctae, and some the size of setal bases (fig. 161); usually with 11 or 12 usurped setae (but rarely with as few as 10 or as many as 17); none of usurped setae in line with *PLs;* antesensillary ridges well developed. *fletcheri* Gater, 1932 (=*spinulosa* Radford, 1946) (p. 55)

With only micropunctae on scutum (fig. 21); with 17 to 20 usurped setae of which 1 to 3 (usually 2) are in line with *PLs;* antesensillary ridges weakly developed, usually inapparent ....*darita,* n. sp. (p. 12)

28(25) Scutum roughly pentagonal by virtue of being broadest at *PLs,* and being angled here, and with lateral margins beyond *PLs* declivate; caudally rather angulate (figs. 192, 193) 29

Scutum subovate behind *ALs;* caudal margin rounded (fig. 29) or subtruncate (fig. 37)..................................30

29(28) With 9 usurped scutal setae (fig. 193)..*longipili* (Radford, 1946) (p. 72)

With 6 usurped scutal setae (fig. 192). *crocidura* (Radford, 1946) (=*lancearia* Radford, 1946) (p. 71)

30(28) *PSB* approximately 100 microns; *PLs* very short, only about 17 microns in length; with 8 usurped setae on scutum (fig. 189) ....*rutila* Gater, 1932 (p. 70)

PSB greater than 116; *PLs* over 36 microns in length; usually with 6 usurped setae, rarely with 7 to 9 (fig. 53).........31

31(30) Scutum more than twice as long as broad (fig. 29). *neterella,* n. sp. (p. 14)

Scutum 1½ times as long as broad (fig. 37) or less (fig. 53).........32

32(31) With *PSB* more than 3 times *AW* (fig. 194); palpal femoral seta nude......................*romeri* Womersley, 1952 (p. 74)

With *PSB* 2½ times *AW* or less (figs. 37 and 53); palpal femoral seta barbed (figs. 38 and 54)..........................33

33(32) With all usurped setae approximately equidistant from midline (fig. 37); scutum distinctly constricted near caudal margin ....*tenella,* n. sp. (p. 16)

With the first pair of usurped setae displaced lateral, not in line with others (fig.53); scutum broadly and evenly ovate ....*tylana,* n. sp. (p. 21)

COMMENTS ON THE SUBGENUS *GAHRLIEPIA*

TAXONOMIC NOTES

Although the species of this subgenus often differ markedly from one another in regard to ornamentation of the scutum and numbers

and position of scutal setae, they are remarkably uniform in certain particulars. The sensory setae of the legs, described for *G. exilis,* new species, are the same in all known chiggers of the subgenus *Gahrliepia,* and incidentally the same pattern occurs without variation in the subgenus *Schöngastiella.* (The subgenus *Walchia* has not yet been studied by us in this regard.) This may very well prove to be a generic character. This group of chiggers is, therefore, in marked contrast to *Trombicula,* in which the setal pattern varies considerably and in which highly modified sensory setae may be present. The palpal setal formula is an excellent taxonomic character in *Trombicula* because of the many specific variations one encounters, but here again the subgenus *Gahrliepia* seems to be much more consistent. The palpal femoral seta is barbed in 28 of the 33 species. (The exceptions are: *rutila* Gater, 1932; *ciliata* Gater, 1932; *romeri* Womersley, 1952; *lawrencei* Jadin and Vercammen-Grandjean, 1952; and *philipi* (Jadin and Vercammen-Grandjean, 1952).) The dorsal seta of the palpal tibia is nude in 26 species, while the lateral seta of this tibia is barbed only in *G. exilis,* new species.

It is difficult to place the species of *G.* (*Gahrliepia*) in natural groups. At first thought it would seem that an obvious division would be to classify the species as scrobiculate ("ornate") versus nonscrobiculate. However, there is no real evidence to indicate that the scrobiculate species are truly related to one another. On the contrary, the *Gahrliepia* with scrobiculi may more likely prove to form a heterogeneous group. For example, in *G. evansi,* new species, *tessellata,* new species, *tuberculata,* new species, *ampullata,* new species, *penetrans,* new species, *ornata* Womersley, 1952, and *decora* Womersley, 1952, coxa III is nearly or actually as broad as long. However, in the other 4 "ornate" species, this coxa is one and two-tenths to one and a half times as long as broad, thus agreeing with the vast majority of nonscrobiculate species. The exceptions in the last group are interesting—3 of the 4 species in which the *PL* setae are displaced so as to be very close to the *ALs* also have very broad coxae III. The ratio of *PW* to the length of the third tarsus varies in this subgenus from 0.75 to 1.84. Again no systematic groupings are possible, for both the extremes noted appear in scrobiculate species. Half of the known forms have only 4 usurped setae, but these chiggers share no other exclusive feature in common. It is apparent that as yet too little is known about this subgenus of trombiculids to properly delimit groups of species.

An African genus near *Gahrliepia* is discussed at the present time in order to compare it with *Gahrliepia* and to avoid bibliographic difficulties in future citations.

GIROUDIA Vercammen-Grandjean, 1952

1952. *Giroudia* VERCAMMEN-GRANDJEAN, Ann. Soc. Belge Med. Trop., vol. 32, No. 6, pp. 643-644. (Generic description in detail, classification, explanation of name and designation of genotype: *Giroudia longiscutullata* Jadin and Vercammen-Grandjean, 1952.)

1952. *Giroudia* JADIN AND VERCAMMEN-GRANDJEAN, Ann. Soc. Belge Med. Trop., vol. 32, No. 6, p. 637. (Brief generic description, explanation of name and designation and description of genotype: *Giroudia longiscutullata* Jadin and Vercammen-Grandjean, 1952.)

The genus *Giroudia* includes two unusual gahrliepiines from the Belgian Congo. The above citation of Vercammen-Grandjean alone as the author of the genus is based upon the obvious intention of both Jadin and Vercammen-Grandjean rather than upon a strict interpretation of the rule of page priority which would result only in confusion. Our citation is in accordance with paragraph 123, Article 28, of the Copenhagen Decisions on Zoological Nomenclature (1953), under which a decision to ignore page priority in special cases may be made by the first reviser.

The presence of well-developed dorsal teeth on the chelicerae serves to separate *Giroudia* from *Gahrliepia,* although the other characters listed by Vercammen-Grandjean (distance between usurped scutal setae, presence of well-developed eyes, and large size of scutum) apply equally well to certain of the species considered herein by us as *Gahrliepia* (*Gahrliepia*).

It is pertinent to discuss some of Jadin and Vercammen-Grandjean's concepts regarding chaetotaxy. Owing to the limited number of species of *Gahrliepia* available to these authors for study, they designated as "posterolateral setae" those setae which we call *PPL-1,* while the more anterior pair, which we call posterolaterals, were designated as "mediolaterals." In their opinion, the determining factor regarding the homology of the *PL* setae is the level of the maximum breadth of the scutum. The extensive series of *Gahrliepia* in our possession includes setal patterns never seen by Jadin and Vercammen-Grandjean, and supports our contention that the second pair of scutal setae are the true posterolaterals, regardless of position. Thus, in *G. exilis, G. laciniata,* and certain other species, there is no pair of setae at the level of the maximum breadth of the scutum, while the *PLs* are in the site of the "mediolateral setae" (figs. 5 and 110). What we call *PLs* are in this same position in many species which also possess usurped setae at the point of maximum breadth. The second pair of scutal setae, regardless of position, almost invariably are definitely longer and stouter than the usurped setae, and this is another argument for our point of view. In *G. gemina,* new species,

G. plurisetae, new species, and *G. hirsuta* (Radford, 1946), according to our belief, the *PLs* have moved anteriorward until they are adjacent to *ALs,* and thus there appear to be two pairs of *ALs.* If such were not the case, and the Jadin and Vercammen-Grandjean theory were correct, in the case of *G. dupliseta* (fig. 70) one would have to postulate the appearance of 2 sets of *ALs,* of which the second pair is more than twice the length of the first, coupled with the disappearance of *PLs* or the migration of the latter well toward the middle of the scutum.

HOST PREFERENCE AND HABITATS OF THE SUBGENUS *GAHRLIEPIA*

Gahrliepiine chiggers have apparently attained their maximum development in the oriental region (Audy, 1954) (in contrast to the New World, for example, where only one species is known). Nevertheless, they are collected far less often than are *Trombicula* and *Euschöngastia* in southeast Asia. This is particularly true of the subgenus *Gahrliepia,* especially insofar as concerns the species with scrobiculate or honeycombed scutum. Despite intensive collecting in Assam, Burma, Malaya, and Borneo by U. S. Army and Colonial Office Medical Research Units, four scrobiculate species have been described on the basis of only four or fewer specimens, as shown in table 2.

It is quite probable that this scarcity of *Gahrliepia* in collections is apparent rather than real, and is due to our ignorance of the habits of these chiggers rather than to low numbers in nature. For example, until the 1953 Borneo expedition, *G. ampullata,* new species, was represented by but one specimen, and *G. laciniata,* new species, was known only from three specimens, collected from two different kinds of rats. The latter species was collected readily only when it was discovered that instead of clustering in the ears of the rats, as do most *Trombicula* and many *Euschöngastia, G. laciniata* invariably was found singly and the specimens were strongly attached deep in the skin at the base of the stout hairs or vibrissae on the bridge of the nose or muzzle of the hosts. Inasmuch as the chiggers in situ were head down, partially embedded in the hair follicle, and also appressed to the stout hairs in areas where the fur was short and dense, it was difficult to see these *Gahrliepia* without special search. Since they usually stayed firmly attached even when the host had been dead two days, they were not readily dislodged or activated by the usual collecting techniques. Even the detergent washing method usually failed to dislodge them. Once its particular attachment site was observed,

however, it became easy to collect this species by picking specimens up singly by fine-pointed forceps.

This persistence of attachment after death of the host has been noted for other species of *Gahrliepia.* Gater called attention to this habit in *G. fletcheri* in the original description (1932). Fuller (1952) refers to similar but unpublished observations made by the U. S. A. Typhus Commission in Burma regarding undescribed species (referring to *G. exilis,* new species, q.v., and the small form of *G. fletcheri* occurring in Assam and Burma).

Perhaps when we learn more about the true hosts, attachment sites, and ecological requirements of these chiggers, they may be collected more readily. There is another possibility worth investigating,

Table 2.—*Number of specimens and hosts in type series of certain ornate* Gahrliepia

Species of *Gahrliepia*	Number of specimens in type series	Number of hosts	
		Individuals	Species
ornata Womersley, 1952	1	1	1
insigne Womersley, 1952	1	1	1
decora Womersley, 1952	7	1	1
picta, new species	3	3	2
tessellata, new species	8	5	4
evansi, new species	4	3	2
ampullata, new species	6	2	1
granulata, new species	6	5	3

and that is that these species may be burrowing forms, similar to *G. penetrans* (q.v., above).

The function of the deeply pitted scutum can only be guessed in the present stage of our knowledge, if indeed there is a function. If the anterior end of a chigger is deeply inserted into a hair follicle or skin (as *G. laciniata*), or if the species completely burrows into the superficial layers of the skin (as *G. penetrans*), the large pits of the scutum may serve to entrap and hold a useful supply of air. It should be pointed out, however, that scrobiculate scuta are not known to occur in chiggers of the genus *Hannemania,* which burrow into or live under the skin of Amphibia, or in *Apolonia tigipioensis* Torres and Braga, which burrows into the quills of chickens.

When discussing host records of chiggers, one must bear in mind a distinction between ecological and physiological host preferences. Ecological host preferences are those infestations of chiggers which are primarily due to the host's predilection for that specific habitat or terrain which is also favored by the nonparasitic stages of the chigger. A variety of mammals living in or entering that microclime may ac-

quire heavy infestations of such a species of chigger. Physiological host preferences, in contrast, refer to regular or fairly specific infestations of a particular species of host, regardless of the ecological habitat involved. The instance of *Trombicula* (*Leptotrombidium*) *pallida* (Nagayo et al., 1919) in Korea may be cited as an example of ecological preference. Here it was found that 61 percent of the chiggers from the reed vole, *Microtus fortis pelliceus* Thomas, were *T. pallida* (Traub et al., 1953). Such a high percentage at first glance suggests a large degree of host specificity. However, 40 percent of the chiggers on the black-striped field mouse, *Apodemus agrarius mantchuricus* Thomas, also were *T. pallida,* and, in fact, 67 percent of all the *T. pallida* examined were from *A. agrarius.* In contrast, less than 1 percent of the chiggers on the red-backed vole, *Clethrionomys rufucanus regulus* Thomas, were *T. pallida. Microtus* could be found only in very specialized habitats—the thick grass growing along the side of a few streams. On the other hand, *Apodemus agrarius* was common everywhere. Along streamsides it was just as abundant as *Microtus,* and it frequently was found in such habitats when *Microtus* was apparently absent. *Clethrionomys* inhabited the woody slopes 150 feet away from such streamsides and never was trapped near the water. *T. pallida* was therefore apparently most prevalent along the margins of streams, and parasitized the mice that inhabited such areas rather than favoring *Microtus* for purely physiological reasons. Unfortunately, the precise ecological requirements are as yet largely unknown for most groups of trombiculids, but it has been shown that the degree of ground moisture is a major factor in determining which of two North American species, *Trombicula* (*Eutrombicula*) *alfreddugesi* (Oudemans) or *T.* (*E.*) *splendens* (Ewing), may be found in circumscribed areas, and the two populations may coexist only 100 feet apart (Wharton and Fuller, 1952).

The subgenus *Gahrliepia,* as a whole, exhibits some rather pronounced host preferences, which to a great extent are apparently physiological and not ecological. That is, they are apt to be found regularly or frequently on certain kinds of mammals but not on others found in the same environment and with much the same habits, as illustrated in North Borneo on Mount Kinabalu at Tenompak (4,500 feet elevation). Although *Rattus w. whiteheadi* Thomas, *Rattus cremoriventer* Miller, *Rattus a. alticola* Thomas, and *Rattus rajah* Thomas were frequently trapped alongside the lesser gymnuran, *Hylomys suillus dorsalis* Thomas (an insectivore), these mammals differed greatly as regards their infestations of chiggers. *Hylomys*

invariably was very heavily parasitized with chiggers, carrying an average of at least 250 chiggers per individual. Samples of 25 to 75 chiggers from 32 such *Hylomys* have failed to yield any *Gahrliepia.* Twenty-nine of these *Hylomys* had been examined carefully by means of the dissecting microscope and particular attention paid to known anatomical sites for *Gahrliepia,* as along bases of hairs of the snout and in or on the perineum. On the other hand, certain of the rats, particularly *Rattus whiteheadi* and *R. alticola,* living in the immediate vicinity were parasitized with *Gahrliepia,* as shown in table 3. The tree shrews, *Tupaia montana baluensis* Lyon, frequently trapped or shot on the ground in the same environment as the *Hylomys* and *Rattus,* never carried *Gahrliepia* even though inevitably very heavily infested with chiggers. Many specimens of *Trombicula* and *Euschöngastia* were collected from ground-dwelling and tree-dwelling squirrels, but no *Gahrliepia* were ever taken, as noted in the table. The absence of *Gahrliepia* on tree-dwelling squirrels may be partially ecological in nature.

The subgenus *Gahrliepia* in general exhibits much the same sort of host preference as indicated for the Borneo species just discussed. We have been able to locate a total of 720 [15] actual specimens or individual specific determinations of *Gahrliepia* in the literature. Of these, 462 specimens (64 percent) were from various species of rats; 107 (15 percent) were from shrews, 114 (16 percent) were from *Tupaia,* a tree shrew; 14 specimens were from moles; 31 from ground-dwelling squirrels (*Menetes* and *Lariscus*); one from an African bat (i.e., *G. nanus*), and one from a Malayan *Hylomys.* It will be noted that no specimens are listed as having been from amphibians, reptiles, birds, or tree squirrels. However, Gater mentions an unspecified number of *G. fletcheri* as having been collected on the tree-dwelling *Callosciurus caniceps* Gray. The other references in the literature, which cite only hosts and do not include data on numbers of specimens, all mention only ground-dwelling rodents or insectivores as hosts. Despite the fact that *Gahrliepia* specimens are collected only relatively infrequently, as compared to *Trombicula* and *Euschöngastia,* it is safe to conclude that the subgenus mainly parasitizes rats, mice, shrews, and tree shrews, and rarely if ever occurs on tree squirrels or birds or cold-blooded vertebrates.

The subgenus *Gahrliepia* includes a relatively high proportion of species that have been found only in the primary forest. Although these species have been collected only infrequently, it is probable that

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[15] It is reiterated that this number refers to individual specimens or records of such, and not to numbers of collections or to hosts.

TABLE 3.—*Comparison of certain mammals as hosts for* Gahrliepia (Gahrliepia) *species and for other chiggers at Tenompak region (4,500 feet elevation), Mount Kinabalu, North Borneo*

Host	Habitat	*Gahrliepia laciniata*	*Gahrliepia tuberculata*	*Gahrliepia penetrans*	*Gahrliepia granulata*	*Gahrliepia ampullata*	*Trombicula* species	*Euschöngastia* species
Rattus whiteheadi	G.	0	Few	Rare(?)	Rare	Rare	Common	Common
Rattus alticola	G.	Common	0	0	Few	0	Rare	Few
Rattus sabanus	G.	Rare	Few	0	0	0	Few	Common
Rattus rajah	G.	Rare	Few	0	0	0	0	0
Hylomys suillus	G.	0	0	0	0	0	Common	Common
Callosciurus notatus	T.	0	0	0	0	0	Common	Common
Callosciurus nigrovittatus	T.	0	0	0	0	0	Common	Common
Callosciurus hippurus	T.	0	0	0	0	0	Common	Common
Callosciurus adamsi	T.	0	0	0	0	0	Common	Common
Glyphotes simus	T.	0	0	0	0	0	Common	Common
Dremomys everetti	T. & G.	0	0	0	0	0	Common	Common
Nannosciurus whiteheadi	T. & G.	0	0	0	0	0	Common	Common
Callosciurus jentincki	T. & G.	0	0	0	0	0	Common	Common
Tupaia montana	T. & G.	0	0	0	0	0	Common	Common
Dendrogale melanura	T. & G.	0	0	0	0	0	Common	Common

O = absence of chiggers; G. = ground-dwelling host; T. = tree-dwelling host; T. & G. = hosts dwelling on both trees and ground.

they are true denizens of the uncut jungle because these forms were never taken in secondary vegetation or scrub terrain despite particularly intensive collecting therein by the U. S. A. Typhus Commission, the U. S. Army Medical Research Units, and the Colonial Office Medical Research Unit. The following are therefore considered inhabitants of *primary* forest: *G. exilis,* new species, *G. neterella,* new species, *G. gemina,* new species, *G. evansi,* new species, *G. picta,* new species, *G. laciniata,* new species, *G. tessellata,* new species, *G. crenulata,* new species, *G. cetrata* Gater, 1932, *G. ornata* Womersley, 1952, *G. decora* Womersley, 1952, *G. insigne* Womersley, 1952, and *G. rutila* Gater, 1932. The following chiggers are known only from the *mountain* forests of Borneo or Malaya (elevation approximately 4,500-5,500 feet): *G. laciniata, tessellata, ampullata, penetrans, granulata,* and *cetrata.* Ten of the eleven scrobiculate ("ornate") species (all except *G. tuberculata,* new species) are included in this list of jungle forms.

SUMMARY

The subgenus *Gahrliepia* includes 33 species, of which 3 are African and the remainder from Asia. Eighteen new species, from Burma, Assam, Thailand, Malaya, and Borneo are described and figured in detail. All previously known species are discussed, and critical structures are illustrated where possible. A key to the species is included. *Gateria* Ewing, 1938, is considered an outright synonym of the subgenus *Gahrliepia* as here defined. It is pointed out that the rarity of many of the species of *Gahrliepia* may be apparent rather than real, owing to our ignorance of the true hosts and particular sites of attachment of the chiggers. Thus, one new scrobiculate ("ornate") chigger, *G.* (*G.*) *laciniata,* was found in abundance only after it was noted that, unlike most trombiculids, this chigger did not attach to the ears, but instead attached at the bases of the stout spiny hairs on the muzzle of the host, *Rattus alticola. G. penetrans,* new species; another scrobiculate form from Borneo, burrows completely into the perineum of the host, *Rattus whiteheadi.* Names and data for additional new species follow, and those with a scrobiculate scutum are marked with an *: *exilis* (primary jungles of North Burma); *fimbriata* (North Burma); *darita* (Assam and North Burma); *neterella* (from various jungle-inhabiting rats in Malaya); *tenella* (Malaya); *elbeli* (from *Menetes,* a ground-inhabiting squirrel in Thailand); *tylana* (from *Bandicota* and *Menetes* in Thailand); *gemina* (from rats and shrews in primary jungle in North Burma); *dupliseta* (Assam); *plurisetae* (from the shrew *Suncus,* Assam);

evansi * (from *Rattus* in primary forest of North Burma); *picta* * (from jungle-inhabiting *Rattus* in Malaya); *tessellata* * (from various *Rattus* and from a ground squirrel and gymnuran in the primary jungle in Malaya); *tuberculata* * (from several kinds of rats in various ecological formations in Borneo); *ampullata* * (North Borneo); *granulata* * (North Borneo rats in mountain forest).

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LOWER CAMBRIAN PTYCHOPARIID TRILOBITES FROM THE CONGLOMERATES OF QUEBEC

(With 6 Plates)

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Baltimore, Md.

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(With 6 Plates)

INTRODUCTION

In a previous paper (Rasetti, 1948) the writer described the Lower Cambrian trilobites occurring in the conglomerate boulders of the lower St. Lawrence valley, to the exclusion of the superfamily Ptychopariidea.[1] The present paper completes the description of the fossils of Early Cambrian age. The material in hand is exceptionally well preserved in limestone, and its illustration may bring a contribution to the knowledge of this difficult group of trilobites. Most of the specimens were collected by the writer during the summers of 1941 to 1946, in part with the aid of a grant from the Penrose Bequest of the Geological Society of America. Some of the species were already described on the basis of material collected by Walcott and preserved in the U. S. National Museum. Fifteen species, nine of them new, are described, and three new genera are established. In addition, six new forms are described but left unnamed. All the type material was deposited in the U. S. National Museum collections.

OCCURRENCE AND AGE OF THE FOSSILS

The fossils here described, as those illustrated in the previous paper (Rasetti, 1948), were recovered from limestone boulders in presumably Lower Ordovician conglomerates (Rasetti, 1946) outcropping at various localities on the south shore of the St. Lawrence River, from Levis to Grosses Roches in Matane County. A list of the localities

[1] There is no generally accepted ending for trilobite superfamilies. The writer successively used the endings -idea and -oidae. Until an agreement is reached among trilobite students, it seems expedient to use the same ending as in the 1948 paper.

and ages of the fossiliferous boulders was given in another paper (Rasetti, 1945a). Boulders are indicated by letters designating the locality (B=Bic, G=Grosses Roches, L=Ville Guay, M=Metis, O=Island of Orleans, SS=St. Simon) followed by a number characterizing the particular boulder.

In view of the abundance of boulders containing early Medial Cambrian fossils at most of the localities (except Bic, where Middle Cambrian boulders seem to be excessively rare), it was not always easy to ascertain the Early Cambrian age of the fossils. Since the writer (Rasetti, 1951) considers post-olenellian strata of the Appalachian and Cordilleran provinces as Medial Cambrian, boulders were considered of Early Cambrian age only if they contained olenellids, or other genera known to occur in association with olenellids, such as *Bonnia* and *Zacanthopsis*. All the boulders from which the described fossils came satisfy this criterion except boulder M-9, which supplied two species. In this case the assignment to the Lower Cambrian is probable but not absolutely certain.

All the described fossils seem referable to the late Early Cambrian *Bonnia-Olenellus* zone (Rasetti, 1951), equivalent to the *Antagmus-Onchocephalus* zone of Lochman (1947, 1952). For reasons already indicated (Rasetti, 1951), the writer prefers to avoid generalized ptychopariid genera for faunal zone designation. Usually each boulder yielded but a few species, and the material is too meager to allow an extensive study of the associations and thereby a clear discrimination of faunules within the zone in the area. As indicated in the previous paper (Rasetti, 1948), an assemblage occurring in a darker limestone (the only kind found in the Ville Guay conglomerate at the type locality and on the Island of Orleans), characterized by species of *Pagetides, Periommella yorkensis* and *Periomma walcotti,* seems to constitute a distinct faunal unit, possibly somewhat younger than the faunule of the light-gray limestone predominating at Bic, Metis, and Grosses Roches. However, the presence of common species (e.g. *Bonnia laevigata*) indicates that the age difference cannot be considerable.

Table 1 lists the species collected from each boulder, including those previously described, in order to facilitate a quick survey of the faunal associations.

All the fossils described herein are well preserved in limestone and show no flattening and, at worst, a very slight degree of distortion. The test is preserved in all but a few specimens.

Table 1.—*Faunal associations in the Lower Cambrian boulders*

Species	Boulder														
	B-4	B-5	B-6	G-1	G-9	G-15	G-17	G-19	G-24	G-25	G-41	L-2	M-10	O-1	O-37
Antagmus elongatus Rasetti				X			X				X		X		
gigas Rasetti		X		X	X	X									
Austinvillia virginica Resser										X					
Bicella bicensis (Resser)														X	
Eoptychoparia angustifrons Rasetti	X														
intermedia Rasetti								X							
normalis Rasetti			X												
Luxella crassimarginata Rasetti			X												
Onchocephalus sulcatus Rasetti											X				
Periomma gaspensis Rasetti									X						
walcotti Resser															X
Periommella yorkensis Resser									X			X			X
Bonnia brennoides Rasetti					X										
crassa Resser			X												
brennus (Walcott)		X				X									
laevigata Rasetti				X			X		X		X	X			
sculpta Rasetti				X			X				X				
tensa Resser										X					
sp. undet.									X			X		X	X
Dolichometopsis bicensis Rasetti	X		X												
Kootenia cf. *K. marcoui* (Whitfield)								X	X						X
Pagetides amplifrons Rasetti												X			
elegans Rasetti									X						
leiopygus Rasetti												X			
minutus Rasetti														X	
rupestris Rasetti									X						
Protypus marginatus Rasetti	X									X					
typicus (Resser)								X	X				X	X	
Prozacanthoides, sp. undet.	X							X				X		X	
Zacanthopsis virginica Resser						X				X			X		
Undetermined Olenellidae			X						X	X					

TERMINOLOGY

The terminology here employed for describing the trilobite exoskeleton is essentially the same as that proposed by Howell et al. (1947), with the modifications listed below.

Several trilobite students have pointed out the opportunity of restoring the term "fixed cheeks" to its original meaning of the entire nonaxial area of the cranidium, instead of a portion thereof. Consequently, the area designated as "fixed cheek" by Howell et al. is now called "palpebral area" and is bounded by the dorsal furrow, the ocular ridge, the palpebral furrow, and a straight line running from the posterior end of the palpebral lobe to the proximal end of the posterior marginal furrow. The term "width of the palpebral area" hence replaces "width of the fixed cheeks" as employed by Lochman (1947), indicating the transverse distance between the dorsal furrow and the palpebral furrow. This distance is often compared to the width of the glabella measured at its midlength. The length of the palpebral lobe is measured along a chord.

The term "frontal area" indicates collectively the preglabellar field, marginal furrow and border.

Terms such as "wide," "long," etc. are qualified by the abbreviations "sag." (sagittal), "exsag." (exsagittal) and "tr." (transverse) whenever the direction in which the measurement is taken might otherwise result in ambiguity.

The posterior limb is divided into a proximal portion, extending from the dorsal furrow to the palpebral lobe, and the remaining distal portion. The ratio of the widths (tr.) of the two portions supplies a useful taxonomic character. The entire width (tr.) of the posterior limb is compared to the width (tr.) of the occipital ring. The width of the posterior limb is measured along a chord, not the vertical projection.

All descriptions refer to the upper surface of the test unless otherwise indicated.

SYSTEMATIC DESCRIPTIONS

Superfamily PTYCHOPARIIDEA

Family PTYCHOPARIIDAE Matthew, 1888

The Lower Cambrian ptychopariids are notoriously difficult to classify (Lochman, 1947; Rasetti, 1951). Study of the new material further emphasizes intergrading of the established genera and the difficulty of adopting such stringent discriminatory generic characters as proposed by Lochman (1947), since adherence to this method

would result in erecting a new genus for almost every new species.

All the genera described herein seem referable to the family Ptychopariidae, containing the generalized forms of the superfamily, excepting *Rimouskia,* which stands out because of the peculiar pattern of the glabellar furrows. This genus, following Hupé, is assigned to the family Saoidae.

The genera based on Lower Cambrian Ptychopariidae of North America are listed with their type species in the order of date of publication.

Kochiella Poulsen, 1927 (*Kochiella tuberculata* Poulsen). No Lower Cambrian forms referable to the genus are known to the writer outside of Greenland. Middle Cambrian forms from the Cordilleran province resemble *Kochiella* in the cephalic features, but no definite reference is possible until a pygidium can be assigned with certainty to the genus (Rasetti, 1951).

Inglefieldia Poulsen, 1927 (*Inglefieldia porosa* Poulsen). Another Lower Cambrian genus with the essential cephalic characters of *Amecephalus* and *Alokistocare.* The writer does not know of any forms outside of Greenland referable to the genus.

Proliostracus Poulsen, 1932 (*Proliostracus strenuelliformis* Poulsen). Chiefly distinguished from similar forms by the greater length and more anterior position of the palpebral lobes. The writer agrees with Lochman in restricting the name to the Greenland species.

Billingsaspis Resser, 1935 (*Conocephalites vulcanus* Billings). Lochman remarked that the type species is based on a generically and specifically unidentifiable cranidium. Hence *Billingsaspis* is to be discarded.

Antagmus Resser, 1936 (*Antagmus typicalis* Resser). This is one of the unfortunate borderline cases, where the holotype of the type species is neither well enough preserved to ascertain the precise characters of the species nor unidentifiable to the point of requiring discarding of the genus. Since one of the species from the Quebec conglomerates seems to agree with *Antagmus typicalis* in all characters that can be observed on Resser's holotype, it is assumed that it belongs to *Antagmus* and the diagnosis of the genus is completed accordingly.

Poulsenia Resser, 1936 (*Solenopleura grönwalli* Poulsen). Although Resser based the genus on a species described from a single cranidium lacking most of the glabella, the cranidial features are fairly well known from the other species described by Poulsen. Examination of the casts of the types suggests that Poulsen's *Solenopleura borealis, S. bullata, S. grönwalli,* and *S. similis,* each based on a single cranidium, belong to one and the same species, the differences

being well within the limits of individual variability in conspecific populations observed in similar Cambrian trilobites. From the combined features of these four cranidia, it seems that *Poulsenia* is close to *Antagmus,* the chief difference being in the slight convergence of the anterior facial sutures viewed from above. No other species seem to possess the same combination of characters; hence *Poulsenia* is provisionally restricted to the Greenland species.

Syspacephalus Resser, 1936 (*Agraulos charops* Walcott). The type species is well represented and was recently refigured by the writer (Rasetti, 1951) with the descriptions of several lower Middle Cambrian species. A genus rather well characterized by the anterior position of the eyes and the slight convergence of the anterior facial sutures.

Onchocephalus Resser, 1937 (*Ptychoparia thia* Walcott). The type species is fairly well known from several cranidia (Rasetti, 1951). Intermediate forms link the genus with *Antagmus, Crassifimbra,* and the Lower Cambrian species which Resser incorrectly referred to *Proliostracus* and *Phychoparella.* Hence the limits of the genus are to a great extent arbitrary.

Periomma Resser, 1937 (*Periomma typicalis* Resser). The remarks concerning *Antagmus* also apply to this case. The type species, represented by distorted cranidia lacking the test, is characterized by the elevation of the palpebral area and of the anterior border. The genus appears to be valid.

Austinvillia Resser, 1938 (*Austinvillia virginica* Resser). A valid genus, based on a well-represented species. However, a second form described by Resser does not appear congeneric with the type species, and is here used as the type of a new genus.

Litocodia Resser, 1938 (*Litocodia typicalis* Resser). Lochman commented on the poor preservation of the type material and referred the species to *Antagmus.* Even though this assignment is not definitive, the name *Litocodia* should be restricted to the type species until this becomes better known.

Periommella Resser, 1938 (*Periommella yorkensis* Resser). A distinctive genus, here described in detail.

Crassifimbra Lochman, 1947 (*Onchocephalus walcotti* Resser). The type species, represented by good limestone cranidia, seems distinct enough from *Onchocephalus* to warrant a separate genus. However, intermediate forms are known.

Piazella Lochman, 1947 (*Ptychoparia pia* Walcott). The type species is characterized by a relatively smaller glabella than most of the other mentioned genera. However, intermediate forms bridge the

gap between *Piazella pia* and species referred by Resser to *Ptychoparella, Antagmus,* and *Onchocephalus.*

Sombrerella Lochman, 1948 (*Sombrerella mexicana* Lochman). No species other than the type seem to possess the same combination of characters.

In addition, Lower Cambrian ptychopariids have been referred to *Ptychoparella* Poulsen, 1927, by Resser and Lochman. The writer disagrees with this use of the genus. The type species is *Ptychoparella brevicauda* Poulsen, collected from erratic boulders tentatively indicated by Poulsen as "Ozarkian," now known from the faunal associations to belong in the Middle Cambrian (presumably *Bathyuriscus-Elrathina* zone). *Ptychoparella* is one of the generalized ptychopariids abundant in beds of that age, and as far as known from the scarce material available, there is little to differentiate it generically from such western forms as *Ehmaniella, Clappaspis, Pachyaspis,* etc. Possibly, when *Ptychoparella* becomes better known, one or more of these genera will fall in its synonymy. At present it seems inadvisable to abandon generic names founded on species of well-known morphology and stratigraphic position in favor of a genus based on a species of uncertain age. Hence the use of *Ptychoparella* should be confined to the type species, and it seems least of all justifiable to refer Lower Cambrian species to it.

Another genus of questionable age is *Perimetopus* Resser, 1937. The type species, *Conocephalites arenosus* Billings, was collected from beds of doubtful stratigraphic position. The type cranidium appears similar to *Elrathia, Ehmania,* and other Middle Cambrian genera. Use of this generic name should be restricted to the type species.

Some of the species here discussed supply information on the changes in cranidial features that occur during growth. The most general and conspicuous of these changes are the decrease in the length of the glabella relative to the entire cranidium, and the increase in the rate of tapering of the glabella. Such changes may still affect cranidia which presumably correspond to holaspid stages (see illustrations of *Periomma gaspensis* and *Periommella yorkensis*). Hence great care must be exercised in comparing the proportions of individuals of different sizes. Doubtless specific differences have been based on such growth features.

The writer must correct Lochman's (1947) statement that Lower Cambrian trilobites in general have a thinner test than later forms. While this is certainly true for the olenellids, it does not apply to the corynexochids and ptychopariids, which may have as thick tests as any later trilobites of comparable size. The species of *Bonnia* illus-

trated by the writer (Rasetti, 1948) and some of the ptychopariids discussed herein supply ample proof. Consequently, the upper and lower surfaces may differ considerably in appearance.

Subfamily ANTAGMINAE Hupé, 1953

A family to contain the most primitive ptychopariids was tentatively erected by Hupé and named after the genus *Antagmus*. The unit is here given subfamily rank since the differences between these Lower Cambrian genera and *Ptychoparia* itself do not seem of great taxonomic significance.

It does not seem possible to assign strict diagnostic features of the Antagminae, since in this difficult group of trilobites taxonomic units cannot be based on morphology alone, without due regard to stratigraphic and geographic factors. The most salient and commonly encountered cranidial features are described, with the understanding that they are not exclusive of the genera included in the subfamily.

The glabella is moderately tapered, always well defined at the sides, in some cases almost merging in front with the preglabellar field. Glabellar furrows moderately deep to obsolete; three or four pairs visible in most species; furrows of four pairs not greatly different in depth, short, straight; first two pairs directed inward and forward, last two pairs inward and backward. Occipital furrow well impressed, occipital ring usually bearing a node, never spinose. Frontal area usually well divided into preglabellar field and border by a marginal furrow; the latter frequently showing a median inbend due to expansion of the border. Palpebral area from one-half to fully as wide as the glabella; ocular ridges present; palpebral lobes elevated, set off by distinct palpebral furrows, from one-fourth to one-half as long as the glabella, situated on the level of the glabellar midpoint, or slightly more forward or backward. Posterior limbs on the average as wide (tr.) as the occipital ring, deeply furrowed. Anterior facial sutures slightly convergent to slightly divergent; frontal portion ventral-intramarginal. Surface of test almost invariably granulated.

Most of the Antagminae are known only from cranidia. However, the writer (Rasetti, 1951) described complete exoskeletons of several lower Middle Cambrian species of *Syspacephalus*. Lochman (1952) figured pygidia attributed to species of *Onchocephalus*. Resser (1938) illustrated a complete, but poorly preserved Lower Cambrian ptychopariid, *"Ptychoparella" buttsi*, referred by Lochman (1947) to the genus *Antagmus*. All these observations confirm that the Antagminae have a thorax of about 15 segments, with pleura bluntly ter-

minated, and a small pygidium, composed of very few segments, which is unlikely to offer generic taxonomic characters.

The writer would provisionally include in the Antagminae only the genera based on Lower Cambrian type species, *Antagmus, Austinvillia, Crassifimbra, Onchocephalus, Periomma, Piazella, Poulsenia, Proliostracus, Sombrerella,* and *Syspacephalus;* also three new genera described herein, *Eoptychoparia, Bicella,* and *Luxella.* Some of the above-mentioned genera are known to range into the lower Middle Cambrian, and it is possible that genera based on Middle Cambrian type species such as *Arellanella, Caborcella,* and several others should also be included. However, a revision of the taxonomy of the Middle Cambrian ptychopariids is a task of such proportions that the writer prefers, for the time being, to confine attention to classification of the Lower Cambrian genera alone. For analogous reasons, genera based on European, African, Australian, Asiatic, and South American forms were not taken into consideration; however, few ptychopariids are known from the Lower Cambrian of these areas.

Representative species of each of the genera described in this paper are illustrated by line drawings on plate 1.

Genus ANTAGMUS Resser, 1936

Description.—Glabella of regular convexity, rounded in front, with three or four pairs of furrows; occipital furrow impressed. Frontal area steeply downsloping at the sides, divided into preglabellar field and border; marginal furrow with a median inbend caused by a rearward expansion of the border. Preglabellar field never completely absent medially. Palpebral area convex, on the average horizontal, from 0.5 to 0.7 times the width of the glabella at its midpoint; ocular ridges well marked; palpebral lobes one-third to one-fourth as long as the glabella, situated slightly back of the glabellar midpoint. Posterior limbs as wide (tr.) as or a little wider than the occipital ring: distal portion as wide as or somewhat narrower than the proximal portion; marginal furrow deep, reaching the distal end of the limb. Anterior facial sutures divergent at least for some distance in front of the eyes, convex outward; frontal portion marginal or slightly ventral for a considerable distance. Posterior branch directed rather definitely outward behind the eye, curving backward near the posterior margin. Surface of test usually with fine granules.

Type species.—*Antagmus typicalis* Resser.

Remarks.—The above description was based chiefly on *Antagmus gigas,* a species here described which seems extremely close to or possibly identical with the poorly represented type species.

Antagmus is difficult to separate from *Onchocephalus* and *Piazella,* as intergrading forms between all these three genera are known and the boundaries must be set arbitrarily. *Antagmus* is chiefly characterized by the strong convexity of the separate cranidial parts, median expansion of the border, and divergence of the anterior facial sutures. Lochman (1947) attributed much importance to the relative transverse width of the palpebral area, a character which is affected by individual variability, stage of growth, and manner of preservation. The writer is more inclined to consider the divergence of the anterior facial sutures as the main diagnostic feature that separates *Antagmus* from *Onchocephalus. Piazella* differs from *Antagmus* mainly in the lack of a considerable medial expansion of the border, definitely downsloping palpebral area, and relatively wider (tr.) posterior limbs.

ANTAGMUS GIGAS Rasetti, new species

Plate 1, figure 1; plate 2, figures 1-8

Available material.—About a dozen cranidia, most of which are fragmentary.

Description.—Entire cranidium of considerable convexity. Glabella defined by a deep dorsal furrow at the sides, a shallower furrow in front, convex in both directions, moderately tapered, with slightly concave sides, rounded in front. Four pairs of glabellar furrows visible, the first pair shallow and short, the other three well impressed. Occipital furrow deep; occipital ring short (sag.), bearing a small node. Frontal area sloping down steeply at the sides; marginal furrow deep at the sides, shallower medially where it bends backward to form an obtuse angle and greatly reduce the preglabellar field. Border convex laterally, flatter and expanded backward medially. Palpebral area rising sharply above the dorsal furrow, especially in exfoliated specimens, convex transversely, on the average horizontal, 0.6 to 0.7 times the width of the glabella at its midpoint; possibly of greater relative width in smaller cranidia. Ocular ridges wide and low, almost straight. Palpebral lobes slightly less than one-third the glabellar length, slightly elevated, situated slightly back of the level of the glabellar midpoint; palpebral furrows shallow. Posterior limbs slightly wider (tr.) than the occipital ring; marginal furrow wide and deep, reaching the distal end of the limb. Anterior facial sutures divergent in front of the eyes in dorsal view, convex outward, curving gradually inward and crossing the margin well at the sides; frontal portion slightly ventral. Posterior branch directed almost straight outward and backward, curving definitely backward only near the margin.

Surface of test finely and densely granulated, showing in addition scattered larger granules. Of these, four pairs are symmetrically placed on the glabella. The surface of the internal cast appears punctate and shows faint anastomosing ridges on the preglabellar field.

Cranidia range from 8 to 20 mm. in length. This is the largest Lower Cambrian ptychopariid known to the writer.

Remarks.—The present form agrees with *Antagmus typicalis* in all characters observable on its holotype cranidium, which, however, is too poorly preserved to show specific features. Hence it would be improper to attempt identification with that species, and a new name is proposed.

Occurrence.—Boulder B-5, Bic (type locality); also boulders G-1, G-9, and G-15, Grosses Roches.

Types.—Holotype: U.S.N.M. No. 123853. Paratypes: U.S.N.M. Nos. 123854-5.

ANTAGMUS ELONGATUS Rasetti, new species

Plate 2, figures 11-16

Available material.—A dozen well-preserved cranidia and one free cheek.

Description.—Glabella relatively long and narrow, rounded in front, slightly tapered, with slightly concave sides, rather strongly convex transversely, moderately convex longitudinally. Second, third, and fourth pairs of glabellar furrows short, rather shallow; occipital furrow well impressed, occipital ring relatively long (sag.), bearing a node. Frontal area of same relative length (sag.) as in the type species, on the average horizontal medially, downsloping at the sides. Border wide medially, where a rearward expansion deflects backward and almost obliterates the marginal furrow; tapering at the sides on account of the strongly curved anterior outline of the cranidium. Palpebral area moderately convex, on the average slightly upsloping, 0.55 times as wide as the glabella at its midpoint. Ocular ridges wide and low, slightly curved; palpebral lobes elevated, narrow, set off by a distinct palpebral furrow, situated slightly back of the level of the glabellar midpoint; length of palpebral lobe 0.44 times the glabellar length. Distance from posterior end of palpebral lobe to posterior margin slightly less than length of palpebral lobe. Posterior limbs as wide (tr.) as occipital ring; furrow deep and wide, reaching the end. Anterior facial sutures divergent in front of the eyes, convex outward, gradually curving inward and widely rounding off the anterior angles of the cranidium. Free cheek attributed to the species

with a wide, convex border set off by a lateral marginal furrow which becomes shallower posteriorly, before joining the very deep posterior marginal furrow which is an extension of the marginal furrow on the posterior limbs of the cranidium. Genal spine short, rapidly tapered. Surface covered with fine granules, among which are scattered larger granules.

Cranidia range in length from 2 to 7 mm. The smaller cranidia are characterized by relatively shorter palpebral lobes, lesser divergence of the anterior facial sutures, and lesser rearward expansion of the anterior border.

Remarks.—This species could briefly be described as differing from *Antagmus gigas* in being smaller and relatively narrower in all its cranidial parts. It also has longer palpebral lobes and consequently shorter (exsag.) posterior limbs.

Occurrence.—The species, although uncommon, was recovered from a number of boulders: B-1, G-1, G-16, G-17, G-41, and M-10; one cranidium collected at Bic was found in the U.S.N.M. collections. The type locality is boulder M-10, Metis.

Types.—Holotype: U.S.N.M. No. 123856. Paratypes: U.S.N.M. Nos. 123857-9.

ANTAGMUS? LONGIFRONS Rasetti, new species

Plate 6, figures 12-15

Available material.—Three well-preserved cranidia.

Description.—Glabella well defined by the dorsal furrow, prominent, tapered, with slightly concave sides, fairly rounded in front. Four pairs of shallow glabellar furrows; occipital furrow well impressed, occipital ring rather short (sag.), bearing a node. Frontal area well divided into preglabellar field and border by a marginal furrow which bends backward medially almost touching the dorsal furrow in front of the glabella. Border rather flat, tapering in width at the sides. Palpebral area slightly convex and downsloping, 0.50 times as wide as the glabella at its midpoint; ocular ridges straight, rather strongly oblique; palpebral 0.30 times as long as the glabella, narrow, somewhat elevated, defined by a distinct palpebral furrow, situated slightly back of the level of the glabellar midpoint. Distance from posterior end of palpebral lobe to posterior margin slightly greater than length of palpebral lobe. Posterior limbs as wide (tr.) as the occipital ring, rather slender; distal portion somewhat longer than proximal portion; furrow fairly deep, reaching the distal end. Anterior facial sutures slightly divergent in front of eyes, gradually curv-

ing inward as in other species of the genus. Posterior branch turning backward in a wide curve. Surface of test covered with fine granules with larger scattered granules both on glabella and fixed cheeks. Length of largest cranidium 7.5 mm.

Remarks.—The species is assigned to *Antagmus* with a question mark because it departs from the type species in three features which might be considered of generic importance: the almost complete disappearance of the medial preglabellar field, the narrowness and downward slope of the palpebral area. Nevertheless, since the shape of the glabella, direction of the facial sutures, and structure of the frontal border are typical of *Antagmus,* the species may be provisionally placed in that genus.

The species was found associated only with an undetermined *Onchocephalus* and another undescribed form; hence the evidence for its Early Cambrian age is not entirely conclusive. However, the fact that a cranidium of this species in the U. S. National Museum was collected at Bic, where boulders of other than Early Cambrian age are virtually unknown, supplies additional proof.

Occurrence.—Boulder M-9, Metis. Also an unknown boulder at Bic.

Types.—Holotype: U.S.N.M. No. 123860. Paratypes: U.S.N.M. Nos. 123861-2.

EOPTYCHOPARIA Rasetti, new genus

Description.—Glabella of regular convexity, rounded in front, showing three or four pairs of shallow glabellar furrows. Frontal area well divided into preglabellar field and border, usually of equal lengths (sag.). Marginal furrow regularly curved or with a slight median inbend caused by an expansion of the border. Palpebral area somewhat convex, horizontal to slightly downsloping, 0.5 to 0.7 times the width of the glabella. Palpebral lobes about one-third as long as the glabella, at the level of the glabellar midpoint. Posterior limbs about as wide (tr.) as the occipital ring, with furrow reaching the distal end. Anterior facial sutures slightly divergent; posterior branch as in *Antagmus.*

Type species.—*Eoptychoparia normalis* Rasetti, new species.

Remarks.—The features of the species attributed to the genus are about average for Lower Cambrian ptychopariids; hence the genus is difficult to characterize and intergrades with *Antagmus, Piazella,* and *Onchocephalus. Eoptychoparia* essentially corresponds to Resser's and Lochman's conception of *Ptychoparella* as based not on the

type species, the upper Middle Cambrian *Ptychoparella brevicauda* Poulsen, but on the supposed Lower Cambrian representatives. Besides the reasons already mentioned under the family discussion, there seem other valid ones for not referring these Lower Cambrian forms to *Ptychoparella:* (1) the position of the eyes is more posterior in *Ptychoparella* than in *Eoptychoparia;* (2) the anterior facial sutures are slightly convergent in *Ptychoparella,* slightly divergent in *Eoptychoparia;* (3) the pygidium may have more segments in *Ptychoparella,* although much weight cannot be attributed to this character as no pygidium can be assigned with certainty to either genus. The writer carefully considered whether such forms should be assigned either to *Antagmus* or *Piazella,* but the distinguishing features seem worthy of generic distinction.

Eoptychoparia differs from *Antagmus* in the lack of a strong rearward expansion of the border; from *Piazella* in the lesser width of the palpebral area and the posterior limbs, and hence in the greater relative size of the glabella compared to the fixed cheeks; from *Onchocephalus* in the generally more prominent, rounded glabella, deeper glabellar furrows, greater convexity and horizontal position of the palpebral area, and on the average more divergent course of the anterior facial sutures. It is acknowledged that these differences are not of great importance, and intermediate forms exist. However, if lack of intermediate species were required for generic separation, one would have to place most of the Ptychopariidae in a single genus.

Besides the species described herein, the writer would refer to *Eoptychoparia* two species described by Resser, *Ptychoparella taylori* and *P. minor,* although the former, possessing greater relative widths of palpebral area and posterior limbs, forms a perfect transition to *Piazella.* Some of Resser's species of *Ptychoparella* from Vermont may also belong in the genus, but most of them are too poorly preserved to warrant discussion, excepting *P. walcotti* which seems very close to the type species of *Eoptychoparia.*

EOPTYCHOPARIA NORMALIS Rasetti, new species

Plate 1, figure 2; plate 3, figures 5-11

Available material.—A dozen partly fragmentary cranidia.

Description.—Glabella prominent, fairly convex longitudinally and strongly convex transversely, slightly tapered, rounded in front. Four pairs of glabellar furrows visible on some specimens; only third and fourth pairs well impressed. Occipital ring short (sag.), bearing a prominent node. Preglabellar field downsloping, as long (sag.) as

the border; marginal furrow regularly curved, except for a slight median inbend appearing only in some individuals; border convex, tapering in width at the sides. Palpebral area slightly convex, on the average horizontal, 0.7 times as wide as the glabella; ocular ridges well marked, slightly curved; palpebral lobes slightly less than half as long as the glabella, at the level of the glabellar midpoint, somewhat elevated, set off by well-marked palpebral furrows. Posterior limbs deeply furrowed, as wide (tr.) as the glabella; distal portion almost as wide (tr.) as proximal portion. Anterior facial sutures slightly divergent in front of eyes, curving inward after crossing marginal furrow; posterior branch turning backward in wide curve. Surface of test very finely granulated. Length of largest cranidium 9 mm.

Remarks.—The illustrations show the variability observed among cranidia of this species (all recovered from the same boulder) in the rate of tapering of the glabella and the presence of a more or less definite inbend of the marginal furrow. The latter is usually more apparent in smaller cranidia.

Occurrence.—Boulder B-6, Bic.

Types.—Holotype: U.S.N.M. No. 123863. Paratypes: U.S.N.M. No. 123864.

EOPTYCHOPARIA ANGUSTIFRONS Rasetti, new species

Plate 3, figures 1-4

Available material.—A dozen cranidia.

Description.—The species is so similar to *E. normalis* that only the distinguishing features are described. The glabella is proportionately narrower and in most specimens shows slightly concave sides on account of the anterior part tapering less rapidly than the posterior part. The marginal furrow is more regularly curved, as there is almost no trace of a median inbend, and the border is of more even width. The surface granulation is somewhat more apparent than in *E. normalis*. Cranidia range in length from 2 to 6 mm.

Remarks.—In the shape of the glabella this species is almost identical with *E. taylori* (Resser), which, however, has proportionately wider palpebral area and posterior limbs.

Occurrence.—Boulder B-4, Bic.

Types.—Holotype: U.S.N.M. No. 123865. Paratypes: U.S.N.M. No. 123866.

EOPTYCHOPARIA INTERMEDIA Rasetti, new species

Plate 3, figures 12-15

Available material.—Nine cranidia.

Description.—This species also can be described by pointing out the differences from *E. normalis.* The glabella is less rounded in front, presenting a slightly truncate appearance, and is also less prominent. The anterior border is somewhat more elevated. The palpebral area is on the average slightly downsloping instead of horizontal. The anterior facial sutures from the palpebral lobe to the marginal furrow are on the average parallel instead of divergent. Cranidia range from 2 to 5 mm. in length.

Remarks.—It is apparent from the description that this species is intermediate between *Eoptychoparia* and *Onchocephalus,* or more precisely between *Eoptychoparia normalis* and *Onchocephalus sulcatus.* This fact shows the close relationship between the two genera.

Occurrence.—Boulder G-19, Grosses Roches.

Types.—Holotype: U.S.N.M. No. 123867. Paratypes: U.S.N.M. No. 123868.

Genus ONCHOCEPHALUS Resser, 1937

Description.—Glabella sloping down to a low anterior end, straight-sided, truncated in front, with four pairs of shallow furrows. Frontal area divided into preglabellar field and border; marginal furrow usually with median inbend. Palpebral area slightly convex, usually downsloping, 0.6 to 0.8 times as wide as the glabella. Palpebral lobes about one-third as long as the glabella, at the level of the glabellar midpoint. Posterior limbs about as wide (tr.) as occipital ring; distal portion narrower (tr.) than proximal portion; marginal furrow reaching distal end of limb. Anterior facial sutures slightly convergent or parallel in front of the eyes, then curving inward and rapidly converging; posterior branch curving backward to posterior margin.

Type species.—*Ptychoparia thia* Walcott.

Remarks.—*Onchocephalus* is chiefly characterized by the downsloping, truncated glabella, lack of divergence of the anterior facial sutures, and the usually downsloping, at most horizontal, palpebral area. Forms with less convergent facial sutures and horizontal palpebral area intergrade with *Antagmus* or *Eoptychoparia;* species with narrower palpebral area approach *Crassifimbra;* and forms with proportionately smaller glabella link the genus to *Luxella.*

The writer would include in the genus, in addition to the species described by Rasetti (1951) and Lochman (1952), *Antagmus soli-*

tarius Lochman and *Proliostracus goodwini* Resser. Lochman excluded the latter species from *Onchocephalus* on the basis of the slightly lesser width of the palpebral area, a character which the writer does not consider of generic importance.

One new species and several unnamed forms are described herein.

ONCHOCEPHALUS SULCATUS Rasetti, new species

Plate 1, figure 3; plate 3, figures 16-19

Available material.—Two well-preserved cranidia.

Description.—Glabella of moderate elevation, straight-sided, fairly truncated in front; dorsal furrow fairly deep at the sides, shallow anteriorly. Four pairs of glabellar furrows visible, but only third and fourth pairs moderately well impressed. Occipital ring bearing a node. Preglabellar field shorter (sag.) than border medially. Border strongly convex, elevated, expanded medially, causing a slight median inbend of the marginal furrow. Palpebral area convex, on the average almost horizontal, 0.7 times as wide as the glabella. Palpebral lobes strongly elevated, 0.4 times as long as the glabella; distance from posterior end of palpebral lobe to posterior margin about equal to length of palpebral lobe. Posterior limbs as wide (tr.) as occipital ring; distal portion appreciably narrower (tr.) than proximal portion. Anterior facial sutures parellel for a short distance in front of the eyes, appreciably convergent at the level of the marginal furrow; posterior branch reaching margin with a wide curve. Length of holotype cranidium 6 mm. Surface finely granulated.

Remarks.—The species is typical of *Onchocephalus* and closely resembles *O. buelnaensis* Lochman and *O. mexicanus* Lochman, differing mainly in the greater prominence of the anterior border and convexity of the palpebral area.

Occurrence.—Boulder G-41, Grosses Roches.

Types.—Holotype: U.S.N.M. No. 123869. Paratype: U.S.N.M. No. 123870.

ONCHOCEPHALUS, species undetermined No. 1

Plate 3, figure 20

Available material.—One cranidium.

Description.—This form is characterized by an almost unfurrowed glabella with slightly concave side outline. Preglabellar field half as long (sag.) as border on median line. Border very convex, not appreciably expanded backward medially. Palpebral area slightly con-

vex and upsloping, about 0.8 times as wide as glabella; palpebral lobes not preserved. Surface of test granulated. Length of crandium 5 mm.

Remarks.—Although this form is distinctive, it does not seem proper to base a specific name on one cranidium. The closest described species is *Antagmus solitarius* Lochman, which the writer would rather include in *Onchocephalus* on account of the slight convergence of the anterior facial sutures. The present form has shorter (sag.) border and wider palpebral area.

Occurrence.—Boulder M-10, Metis.

Disposition of material.—U.S.N.M. No. 123871.

ONCHOCEPHALUS, species undetermined No. 2

Plate 3, figure 22

Available material.—One perfect crandium.

Description.—Glabella with slightly concave side outline, sharply truncated in front; four pairs of faint glabellar furrows visible. Occipital ring rather long (sag.), rounded in outline. Preglabellar field very short (sag.) medially; border very prominent, convex; marginal furrow of uniform curvature, lacking a median inbend. Palpebral area slightly upsloping, 0.6 times as wide as glabella; palpebral lobes half as long as glabella, elevated; distance from posterior end of palpebral lobe to posterior margin less than length of palpebral lobe. Posterior limbs with deep, straight furrow. Anterior facial sutures parallel for the short distance between palpebral lobes and marginal furrow; posterior branch as in other species of genus. Surface of test finely granulated. Length of cranidium 4 mm.

Remarks.—This distinctive form differs from typical species of *Onchocephalus* in the slightly upsloping rather than downsloping palpebral area and somewhat longer palpebral lobes. The former character brings it somewhat close to *Periomma* (e.g., cf. *Periomma gaspensis,* pl. 4, fig. 15). As the only known cranidium is small, it is possible that some of its features are due to immaturity.

Occurrence.—Boulder G-41, Grosses Roches.

Disposition of material.—U.S.N.M. No. 123872.

ONCHOCEPHALUS, species undetermined No. 3

Plate 3, figure 21

Available material.—One cranidium.

Description.—Glabella straight-sided, moderately truncated in front, sloping down to low anterior end; three pairs of glabellar furrows fairly well impressed. Occipital ring long (sag.). Length (sag.) of

frontal area average for the genus; border prominent, highly convex; marginal furrow regularly curved, with but a trace of a median inbend. Palpebral area 0.8 times as wide as the glabella, slightly upsloping; palpebral lobes half as long as the glabella, elevated; distance from posterior end of papebral lobe to posterior margin less than length of palpebral lobe. Surface of test punctate. Length of cranidium 4.8 mm.

Remarks.—This form agrees with *Onchocephalus* in the shape of the glabella and structure of the frontal area, but differs in the slightly upsloping palpebral area and the greater length of the palpebral lobes. In the last characters and general aspect the species approaches the new genus *Luxella.*

Occurrence.—Boulder B-11, Bic; associated with *Bonnia brennus* (Walcott), *Protypus* sp.

Disposition of material.—U.S.N.M. No. 123873.

Genus CRASSIFIMBRA Lochman, 1947

CRASSIFIMBRA, species undetermined No. 1

Plate 3, figure 23

Available material.—One cranidium.

Description.—Glabella of low convexity, with slightly concave side outline, fairly truncated in front, showing four pairs of very shallow furrows; occipital ring not well preserved. Preglabellar field almost vanishing medially; border of moderate width (sag.), with barely a trace of a median rearward expansion. Palpebral area definitely downsloping, slightly convex, half as wide as the glabella; palpebral lobes not preserved, apparently about one-third the glabellar length. Posterior limbs slightly narrower (tr.) than occipital ring. Anterior facial sutures slightly convergent from eye to marginal furrow; posterior branch as in typical species of *Onchocephalus.* Surface of test finely granulated. Length of cranidium 4 mm.

Remarks.—This species, intermediate in several features between *Onchocephalus* and *Crassifimbra,* is referred to the latter genus on account of the narrowness of the palpebral area. It differs from *Crassifimbra walcotti* (Resser) in the greater relative length of the glabella, deeper dorsal and marginal furrows, elevated and narrow border, and granulated surface.

Occurrence.—Boulder SS-1, St. Simon; associated with *Protypus reticulatus* Rasetti.

Disposition of material.—U.S.N.M. No. 123874.

CRASSIFIMBRA, species undetermined No. 2

Plate 2, figures 9, 10

Available material.—One well-preserved cranidium.

Description.—Glabella of low convexity, straight-sided, with fairly sharp anterior angles; almost merging with the slope of the preglabellar field in front. Occipital ring bearing a node. Preglabellar field greatly reduced medially; border convex, strongly expanded medially, causing a slight inbend of the marginal furrow. Palpebral area slightly convex, horizontal, half as wide as the glabella; ocular ridges not greatly elevated. Palpebral lobes half as long as the glabella, narrow, elevated; distance from posterior end of palpebral lobe to posterior margin somewhat less than length of palpebral lobe. Posterior limbs as wide (tr.) as occipital ring, well rounded distally; distal portion somewhat narrower (tr.) than proximal portion. Anterior facial sutures slightly convergent from eyes to marginal furrow; posterior branch directed straight outward behind eye. Surface of test finely granulated. Length of cranidium 6 mm.

Remarks.—This distinctive species does not exactly fit the characters of any described genus. It seems best placed in *Crassifimbra* on account of the narrowness of the palpebral area. It differs from *Crassifimbra walcotti* in the depth of the dorsal and marginal furrows, horizontal palpebral area, prominence of the anterior border, long palpebral lobes, and granulated surface.

Occurrence.—Boulder B-1, Bic; associated with *Bonnia laevigata* Rasetti, *Protypus* sp., *Zacanthopsis* sp.

Disposition of material.—U.S.N.M. No. 123875.

LUXELLA Rasetti, new genus

Description.—Glabella straight-sided, tapered, not greatly elevated, well defined by the dorsal furrow at the sides, truncated and poorly delimited in front, occupying half the cranidial length. Preglabellar field long (sag.), slightly downsloping; border wide (sag.), slightly convex. Palpebral area flat, horizontal, as wide as the glabella; ocular ridges visible; palpebral lobes elevated, almost half the glabellar length, at the level of the glabellar midpoint. Posterior limbs somewhat wider (tr.) than the occipital ring, well furrowed, with distal part bent downward. Anterior facial sutures divergent in front of the eyes for a considerable distance, curving inward in crossing the border; frontal portion slightly ventral. Posterior branch directed first straight outward, then curving backward to posterior margin.

Type species.—*Ptychoparia lux* Walcott.

Remarks.—The type species has been misplaced in several genera. *Luxella* is obviously a close relative of *Onchocephalus,* as evidenced by an intermediate form illustrated herein (*Onchocephalus,* species undetermined No. 3), showing widening of the palpebral area, lengthening of the frontal area, and increasing size of the palpebral lobes. In *Luxella lux* these changes have reached a point where they justify generic distinction. From these features, it is obvious that *Luxella* resembles *Inglefieldia, Amecephalus,* and *Alokistocare,* and may well be in the ancestral line of some of these trilobites. The chief difference is in the shape of the posterior limbs, which in all these genera have a longer, horizontal distal portion, whereas in *Luxella lux* the distal portion is shorter and sharply turned downward, indicating a thorax with pronounced geniculation in place of the flat pleura of the *Amecephalus* type. Hence the species is not referred to *Inglefieldia,* which it otherwise resembles except in the greater width of the palpebral area.

An additional species from Quebec is referred to *Luxella.*

LUXELLA LUX (Walcott)

Plate 1, figure 4; plate 6, figures 9-11

Ptychoparia lux Walcott, Smithsonian Misc. Coll., vol. 67, No. 3, pl. 12, fig. 5, 1917.

Kochina? lux (Walcott), Resser, Smithsonian Misc. Coll., vol. 97, No. 10, p. 33, 1938.

Crassifimbra lux (Walcott), Rasetti, Smithsonian Misc. Coll., vol. 116, No. 5, p. 82, 1951.

Available material.—The type lot includes the holotype and several paratype cranidia. Among several topotype cranidia collected by the writer is the almost perfect one illustrated herein.

Description.—Most of the characters of the species were mentioned in the generic diagnosis and are not repeated. The glabella shows two very faint pairs of furrows at the sides. Occipital furrow distinct, occipital ring moderately long (sag.), anterior border somewhat narrower (sag.) than the preglabellar field medially; marginal furrow well impressed at the sides but shallow medially owing to a slight rearward extension of the median portion of the border. Posterior limbs appearing as wide (tr.) as the occipital ring in dorsal view, actually somewhat longer because the distal, downturned portion appears shortened. Distal portion of limb half as wide (tr.) as proximal portion. Distance from posterior end of palpebral lobe to posterior margin appreciably less than length of palpebral lobe. Surface of test finely punctate. Length of figured cranidium 6 mm.

Occurrence.—The species is known only from the type locality (U.S.N.M. locality 61d; author's locality P22m): St. Piran sandstone (Peyto limestone member), about 110 feet above base of member; on west ridge of Mount Schaffer, 0.4 miles W. 30° S. of the summit; Yoho National Park, British Columbia. Associated with olenellids, *Bonnia fieldensis* (Walcott) and *Zacanthopsis.*

Types.—Holotype and paratypes: U.S.N.M. No. 64387. Plesiotype: U.S.N.M. No. 123876.

LUXELLA CRASSIMARGINATA Rasetti, new species

Plate 6, figures 7, 8

Available material.—Two cranidia, one of which is poorly preserved.

Description.—Glabella tapered in the posterior three-fifths, parallel-sided in the anterior two-fifths, hence with concave side outline; sloping down to a low anterior end but still well delimited in front. Four pairs of very short and shallow glabellar furrows visible; occipital furrow deep; occipital ring rather long (sag.), bearing a node. Preglabellar field one-third as long (sag.) as the border medially; border upsloping, slightly convex, very long (sag.) at the midline, tapering at the sides; marginal furrow not greatly curved, with barely a trace of a median inbend. Palpebral area horizontal, flat, fully as wide as the glabella; palpebral lobes not preserved, but evidently long; posterior limbs not entirely preserved. Surface of test punctate. Length of cranidium 7 mm.

Remarks.—This distinctive species appears worth naming although represented by imperfect material. It differs from *L. lux* chiefly in the different proportions of the preglabellar field and border, concave lateral outline, and better definition of the glabella.

Occurrence.—Boulder B-6, Bic.

Types.—Holotype: U.S.N.M. No. 123885. Paratype: U.S.N.M. No. 123886.

Genus AUSTINVILLIA Resser, 1938

Description—Glabella tapered, straight-sided, not greatly elevated, moderately rounded in front, faintly furrowed at the sides. Occipital ring short (sag.). Dorsal furrow not very deep. Frontal area of average length (sag.), faintly arched transversely, divided by a faint marginal furrow into a short (sag.) preglabellar field and a long (sag.), convex border. Palpebral area slightly convex, horizontal; ocular ridges of average strength; palpebral lobes narrow, elevated,

about one-third the glabellar length, situated at the level of the glabellar midpoint. Width of palpebral area somewhat over half the glabellar width. Posterior limbs as wide (tr.) as the occipital ring, with a deep furrow reaching the extremity. Anterior facial sutures slightly divergent for some distance in front of the eyes, curving inward after crossing the marginal furrow; frontal portion slightly ventral. Posterior branch first directed straight outward, then curving backward to posterior margin.

Type species.—*Austinvillia virginica* Resser.

Remarks.—The cranidium of *Austinvillia* resembles *Onchocephalus* in the general proportions and convexity but differs in the structure of the frontal area and the slight divergence of the facial sutures. The structure of the frontal area and the lesser convexity of the various parts also distinguish *Austinvillia* from *Antagmus, Eoptychoparia,* and *Piazella.*

The type species is the only described form that can be assigned to the genus. However, a closely similar species is common in leached dolomite at the base of the Parker shale three-fourths of a mile southwest of Parker Cobble, near Georgia, Vt.

AUSTINVILLIA VIRGINICA Resser

Plate 1, figure 5; plate 4, figures 8-10

Austinvillia virginica Resser, Geol. Soc. Amer. Spec. Pap. 15, p. 61, pl. 3, figs. 8-10, 1938.

Available material.—The type lot includes the holotype and two paratypes preserved in limestone. An additional, perfect cranidium was collected by the writer.

Description.—Only details not mentioned in the generic diagnosis are included. The glabella shows four pairs of short furrows of increasing strength. The furrows of the first, third, and fourth pairs start from the dorsal furrow, while the second pair is located somewhat more inward. This feature is common to a great number of both ptychopariid and corynexochid Cambrian trilobites, and its significance is obscure. The occipital ring bears a node. Palpebral lobes slightly exceeding one-third the glabellar length; distance from posterior end of palpebral lobe to posterior margin equal to length of palpebral lobe. Surface finely and rather indistinctly granulated. Length of largest cranidium 14 mm.

Remarks.—The cranidium from Quebec here figured differs slightly from the holotype and paratype illustrated by Resser in the lesser convexity of the border, while it seems identical with a third, un-

figured specimen in the type lot. Hence the small differences may be attributed to intraspecific variability.

Occurrence.—The types are from U.S.N.M. locality 23j: Shady (?) limestone, 1 mile northeast of Austinville, Va. The specimen here figured is from boulder G-25, Grosses Roches.

Types.—Holotype and paratypes: U.S.N.M. No. 94742. Plesiotype: U.S.N.M. No. 123878.

Genus **PERIOMMA** Resser, 1937

Description.—Glabella conical, more or less truncated in front, faintly furrowed at the sides, high posteriorly, not greatly elevated anteriorly. Dorsal furrow very deep laterally. Occipital furrow well impressed, occipital ring rounded. Frontal area consisting of preglabellar field, often with median boss, and strongly convex, swollen border. Palpebral area slightly convex, on the average upsloping; ocular ridges distinct; palpebral lobes slightly raised, about one-fourth the glabellar length, at the level of the glabellar midpoint. Width of palpebral area about three-fourths width of glabella. Posterior limbs about as wide (tr.) as, or slightly wider than, occipital ring; distal portion narrower (tr.) than proximal portion. Posterior marginal furrow deep, but not extending to the end of the limb, indicating that it does not continue onto the free cheek. Anterior facial sutures slightly convergent; frontal portion slightly ventral. Posterior branch first directed outward, gradually curving backward to posterior margin. Test thick; upper surface may be finely granulated.

Type species.—*Periomma typicalis* Resser.

Remarks.—The characters of the genus, based on the poorly represented type species, have been supplemented from two other species, *P. walcotti* Resser and *P. gaspensis* described herein, both appearing to be definitely congeneric with *P. typicalis.* The genus is fairly well characterized by the elevation of the palpebral area, which chiefly distinguishes it from more generalized ptychopariids. However, transitional forms seem to link *Periomma* to *Onchocephalus.*

PERIOMMA WALCOTTI Resser

Plate 1, figure 6; plate 5, figures 9-14

Periomma walcotti Resser, Geol. Soc. Amer. Spec. Pap. 15, p. 92, pl. 3, figs. 14, 15, 1938.

Available material.—The type lot includes the holotype and a paratype. The U.S.N.M. collections include several other topotype

cranidia. Several additional cranidia were collected by the writer, also from the type locality.

Description.—Glabella fairly tapered, straight-sided, not too sharply truncated in front. Three and sometimes four short, shallow glabellar furrows visible at the sides. Occipital furrow almost straight; occipital ring expanded medially, obtusely subtriangular, bearing a node. Preglabellar field somewhat shorter (sag.) than the border on the outer surface, lacking a boss. Border convex, prominent, swollen medially, tapering in width at the sides on account of the straight course of the marginal furrow and the curved anterior outline of the cranidium. Ocular ridges wide and low on outer surface; palpebral lobes set off by a shallow palpebral furrow and not greatly elevated. Width of palpebral area about 0.8 times width of glabella. Posterior limb about as wide (tr.) as occipital ring. Surface with rather indistinct granules. The unusually thick test of this species results in a great difference in the appearance of exfoliated cranidia, where the glabella appears proportionately narrower and the preglabellar field longer (sag.), and all furrows are accentuated.

Remarks.—An exact comparison with the type species cannot be made, since the latter is represented by distorted sandstone casts. The chief difference seems to be the lack of a preglabeller boss in *P. walcotti.*

Occurrence.—All the known specimens are from boulders of the Ville Guay conglomerate. The figured cranidia collected by the writer are from boulder O-24, Island of Orleans. Found also in boulder L-2, Ville Guay.

Types.—Holotype and paratype: U.S.N.M. No. 23529. Plesiotypes: U.S.N.M. No. 123879.

PERIOMMA GASPENSIS Rasetti, new species

Plate 4, figures 11-15

Available material.—Eight cranidia ranging from 3 to 7 mm. in length.

Description.—Most of the characters of this species are either included in the generic diagnosis or are the same as in *P. walcotti.* The chief differences from the latter species are the somewhat shorter (sag.) border, the shallowness of the median portion of the anterior marginal furrow due to the presence of a preglabellar boss, and the greater width (tr.) of the posterior limb, which somewhat exceeds the width of the occipital ring. Surface indistinctly granulated.

A feature observed on this species is the increased rate of tapering

of the glabella with the size of the individual, as clearly shown by the three illustrated cranidia. Note also the resemblance of the smallest cranidium (pl. 4, fig. 15) to *Onchocephalus,* species undetermined No. 2 (pl. 3, fig. 22).

Occurrence.—Boulder G-24, Grosses Roches.

Types.—Holotype: U.S.N.M. No. 123880. Paratypes: U.S.N.M. No. 123881.

BICELLA Rasetti, new genus

Description.—Glabella tapered, straight-sided, sharply truncated in front, defined by a deep dorsal furrow. Glabellar furrows shallow; occipital furrow well impressed; occipital ring expanded medially. Frontal area poorly differentiated into preglabellar field and a wide (sag.), swollen border. Palpebral area convex and somewhat upsloping, less than half as wide as the glabella. Ocular ridges strong, extended into prominent, convex palpebral lobes situated at the level of the glabellar midpoint and one-third as long as the glabella. Posterior limbs as wide (tr.) as occipital ring; distal portion equal to proximal portion. Marginal furrow deep but not attaining the end. Anterior and posterior facial sutures similar to *Periomma.*

Type species.—Austinvillia bicensis Resser.

Remarks.—The type species was assigned to *Austinvillia* on the basis of two imperfect cranidia available to Resser. Much better material now extant shows that this form bears little resemblance to *Austinvillia* and cannot be assigned to any described genus. *Bicella* is probably closest to *Periomma,* from which it differs in the lack of a deep anterior marginal furrow, narrow palpebral area, and larger palpebral lobes. *Bicella* differs from *Austinvillia* in the convergence of the anterior facial sutures, rounded anterior outline of the cranidium, narrowness and convexity of the palpebral area, larger palpebral lobes, deeper dorsal furrow, truncated glabella, and posterior marginal furrow not extending to the end of the posterior limb.

BICELLA BICENSIS (Resser)

Plate 1, figure 7; plate 4, figures 1-7

Austinvillia bicensis RESSER, Geol. Soc. Amer. Spec. Pap. 15, p. 61, pl. 3, figs. 6, 7, 1938.

Austinvillia bicensis Resser, RASETTI, Amer. Journ. Sci., vol. 243, p. 317, pl. 2, figs. 1-4, 1945.

Available material.—The type lot includes the two syntypes, both incomplete, exfoliated cranidia. About a dozen additional cranidia

collected by the writer show the outer surface and all other cranidial features.

Description.—Glabella tapered, truncated in front, strongly convex transversely, with four pairs of very shallow, short furrows visible in some of the specimens. Dorsal furrow deep, especially wide at the sides. Occipital furrow slightly convex backward, somewhat shallower medially; occipital ring expanded medially, bearing a node. Frontal area vaguely divided into preglabellar field and a convex, elevated border in the smaller cranidia, almost undifferentiated in the larger specimens where it shows an almost uniform longitudinal convexity along the midline. At the sides the frontal area has a concave longitudinal profile determined by the steep slope in front of the ocular ridges. Ocular ridges wide and strong, extended into the palpebral lobes without sharp change in direction or elevation; palpebral lobes convex, elevated above the palpebral area. Distance from posterior end of palpebral lobe to posterior margin somewhat shorter than length of palpebral lobe. Anterior facial sutures appearing parallel in dorsal view for a short distance, then gradually converging and widely rounding off the anterior outline of the cranidium; frontal portion ventral-intramarginal. Surface densely covered with granules, larger on the elevated portions and smaller in the depressions. Test thick. Length of largest cranidium 10 mm.

Remarks.—Notwithstanding the imperfect type material, the writer considers the better cranidia illustrated herein unquestionably conspecific. No other known form seems referable to the genus.

Occurrence.—The types are from a conglomerate boulder at Bic. The additional specimens here illustrated were collected from boulder O-1, Island of Orleans. The species is also known from Lower Cambrian beds in place at Ville Guay, Quebec (Rasetti, 1945b).

Types.—Syntypes: U.S.N.M. Nos. 65015-6. Plesiotypes: Laval Univ. Nos. 308a-d, 309a-b; U.S.N.M. No. 123882.

ANTAGMINAE, genus and species undetermined

Plate 6, figures 16-18

Available material.—One well-preserved cranidium.

Description.—Glabella moderately tapered, straight-sided, rounded in front, fairly convex, well delimited by the dorsal furrow. Four pairs of shallow glabellar furrows; occipital furrow well marked; occipital ring rather long (sag.). Frontal area on the average downsloping; border convex, about twice as long (sag.) as the preglabellar field on the midline. Marginal furrow almost regularly curved, medi-

ally somewhat shallower and with a slight inbend. Palpebral area slightly convex and definitely downsloping, 0.4 times as wide as the glabella at its midpoint. Ocular ridges not greatly elevated; palpebral lobes slightly less than 0.3 times as long as the glabella; distance from posterior end of palpebral lobe to posterior margin twice length of palpebral lobe; position of palpebral lobes somewhat in advance of glabellar midpoint. Posterior limbs three-fourths as wide (tr.) as the occipital ring, furrowed to the distal end. Anterior facial sutures approximately parallel from eye to marginal furrow, then curving inward and becoming ventral-intramarginal. Posterior branch directed straight outward and backward for a considerable distance, curving backward close to posterior margin. Upper surface of test faintly punctate. Length of cranidium 7.5 mm.

Remarks.—This species does not possess the characters of any described Lower Cambrian genus. However, it does not seem proper to erect a species, and much less a genus, on a single individual. Possibly a new genus could include this form and the somewhat similar associated species *Antagmus? longifrons.*

Occurrence.—Boulder M-9, Metis.

Disposition of material.—U.S.N.M. No. 123877.

PERIOMMELLINAE Rasetti, new subfamily

The aberrant genus *Periommella* seems to warrant a separate subfamily.

Ptychopariidae with very wide fixed cheeks, palpebral area folded down vertically in front and at the sides, causing the eyes to be concealed in dorsal view. Posterior limbs not extending farther laterally than the palpebral area. Pygidium unknown, presumably very small. Known only from the upper Lower Cambrian of the Appalachian province.

Genus PERIOMMELLA Resser, 1938

Description.—Cranidium proportionately wide and short. Glabella truncatoconical, high posteriorly, sloping down anteriorly, of low longitudinal convexity; glabellar furrows indistinct, occipital furrow impressed, occipital ring long (sag.), elevated. Dorsal furrow very deep at the sides, narrower and shallower in front. Frontal area consisting of short (sag.) preglabellar field and prominent, convex border. Preglabellar area with tendency to develop a median boss. The border may be strongly arched transversely (*P. roddyi*). Palpebral area flat, upsloping, twice as wide as the glabella, folded down vertically in

front and at the sides. Ocular ridges first directed forward and curving backward. Palpebral lobes poorly differentiated within the lateral vertical slope, situated near the level of the glabellar midpoint (*P. yorkensis*) or farther back (*P. roddyi*). Posterior limb not extending laterally beyond the palpebral area, with a deep, wide furrow not reaching the end of the limb. Anterior facial sutures strongly convergent in front of the eyes; frontal portion somewhat ventral-intramarginal. Posterior branch first directed inward, then slightly outward, and inward again before reaching posterior margin. Free cheeks very narrow, dorsally consisting of wide, convex border and small ocular platforms. Test thick; upper surface granulated.

Type species.—*Periommella yorkensis* Resser.

Remarks.—Lochman (1947) gave a diagnosis based on material described herein. Notwithstanding the aberrant features, the similarity in the structure of the glabella, frontal area, and posterior limbs indicates relationship to *Periomma.*

PERIOMMELLA YORKENSIS Resser

Plate 1, figures 8, 9; plate 5, figures 1-8

Periommella yorkensis Resser, Geol. Soc. Amer. Spec. Pap. 15, p. 93, pl. 3, figs. 35, 36, 1938.

Available material.—The type lot consists of the holotype and two paratypes, all poorly preserved as internal casts in weathered sandstone. Numerous excellent cranidia and a few free cheeks in limestone are extant.

Description.—Features included in the generic diagnosis are omitted. Glabella with a trace of four pairs of furrows visible on whitened specimens. Relative lengths (sag.) of preglabellar field and border about equal in average cranidia 6 mm. long. Marginal furrow straight, deeper at the sides, shallow medially on account of a median preglabellar boss that becomes more pronounced in larger individuals. Border very convex, slightly arched transversely, underfolded in front so that the frontal portion of the facial suture has a ventral course. Palpebral area flat and slightly upsloping, but not reaching the level of the glabella; ocular ridges directed outward and forward from the glabella, wide and poorly defined on the upper surface, turning backward in a regular curve and fading out along the margin of the sharp vertical drop of the palpebral area along its anterior edge. Palpebral area also turned down vertically at the sides, so that its lateral margin is concealed in dorsal view. Palpebral lobes hardly differentiated as the marginal portion of the downfolded palpebral area, invisible from

above, delimited only by the sharp turn of the facial suture at either end. Facial suture in front of palpebral lobe directed strongly inward; posterior branch starting from the palpebral lobe inward and backward, then backward and very slightly outward, finally turning backward and inward again before reaching the posterior margin. Posterior marginal furrow deep, terminating in a distal depression, not extending onto free cheeks. Free cheek narrow, with wide, convex border extending into a short, conical genal spine; marginal furrow weakly impressed only in median portion, setting off the small ocular platform rising vertically to the eye. The visual surface has not been observed, and if developed at all it was probably narrow and poorly differentiated.

Surface of test densely covered with very fine granules.

Cranidia ranging from 1.1 to 15 mm. in length supply interesting information on the changes taking place in development. The smallest cranidium (pl. 5, fig. 6) does not show the remarkable specialized features of the adult but is essentially similar to a meraspid cranidium of a generalized ptychopariid. The glabella is parallel-sided and reaches the anterior marginal furrow, the glabellar furrows are fairly well impressed at the sides, and the fixed cheeks lack the peculiar features described above. Cranidia 2 mm. long already show to a considerable degree the characters of the adult, except that the glabella is less tapered and the preglabellar field relatively shorter (sag.). The two last mentioned changes continue to occur even in presumably holaspid cranidia between the lengths of 6 and 15 mm. Note the strongly tapered glabella and great longitudinal extent of the preglabellar field in the largest cranidium (pl. 5, fig. 8).

Occurrence.—The types are from U.S.N.M. locality 48f: Kinzers formation, Smith's Lime Kiln, near York, Pa. The species is common in the boulders of the Ville Guay conglomerate at Ville Guay and the Island of Orleans, and occurs more rarely at Grosses Roches. The illustrated specimens are from boulders O-37, Island of Orleans, and G-24, Grosses Roches.

Types.—Holotype: U.S.N.M. No. 65002. Paratype: U.S.N.M. No. 65003. Plesiotypes: U.S.N.M. Nos. 123883-4.

Family SAOIDAE Hupé, 1953

Genus RIMOUSKIA Resser, 1938

Description.—Glabella relatively long, very prominent, slightly tapered, well rounded in front. Second to fourth pairs of glabellar furrows deep, straight, transverse, of equal length (tr.); occipital

furrow deeper laterally, occipital ring bearing a node or short spine. Frontal area on the average concave, indistinctly divided into preglabellar field and border. Palpebral area downsloping, narrower than glabella; ocular ridges strong; palpebral lobes one-third as long as the glabella, obliquely situated, at level of anterior third of glabella. Posterior limbs with wide furrow; posterior margin with sharp geniculation. Anterior facial sutures convergent; posterior branch directed outward and backward without much curvature. Test coarsely granulated.

Type species.—*Rimouskia typica* Resser.

Remarks.—*Rimouskia* differs from *Sao* in the less tapered, longer glabella, lack of a definite sagittal glabellar furrow, straight posterior branch of the facial suture, stronger and more distally located geniculation of the posterior cephalic border.

The genus is known exclusively from the Lower Cambrian of Quebec.

RIMOUSKIA TYPICA Resser

Plate 1, figure 10; plate 6, figures 1-6

Rimouskia typica Resser, Geol. Soc. Amer. Spec. Pap. 15, p. 98, pl. 3, figs. 20-22, 1938.

Rimouskia spinosa Resser, Geol. Soc. Amer. Spec. Pap. 15, p. 98, pl. 3, fig. 19, 1938.

Available material.—The holotype and a paratype, plus several additional topotype cranidia. Also the holotype of *Rimouskia spinosa.*

Description.—Glabella very strongly convex transversely, almost flat longitudinally excepting the anterior part which drops steeply to the preglabellar field. Glabellar furrows deeply impressed on the lateral thirds of the glabella, in some cranidia showing a tendency to connect between the various pairs through shallow longitudinal extensions of the furrows at their inner ends. Occipital furrow deep in the lateral thirds, shallow medially; occipital ring bearing a short spine, more developed in the smaller cranidia, directed upward. Sagittal length of frontal area 0.30 times the length of the glabella. Concave preglabellar field gradually changing into convex border. Lateral portions of preglabellar field steeply inclined in front of prominent, curved ocular ridges. Palpebral lobes oblique, one-third as long as the glabella, elevated, set off by distinct palpebral furrows; distance from posterior end of palpebral lobe to posterior margin almost twice the length of palpebral lobe. Posterior limbs 1.3 times as wide (tr.) as occipital ring, very broadly furrowed. Posterior border with sharp ge-

niculation at midwidth; distal portion turned downward and forward. Anterior facial sutures strongly convergent in front of eyes, widely rounding off anterior cranidial outline; posterior branch straight, showing little change in direction from anterior branch in dorsal view. Surface of test covered with granules of various sizes. Length of largest (holotype) cranidium 8 mm.

Remarks.—Upon examination of the material in the U. S. National Museum, it appears that the cranidium which Resser singled out as the type of *Rimouskia spinosa* does not differ specifically from *R. typica.* The smaller cranidia seem to possess, on the average, a more pronounced and almost horizontal occipital spine, whereas in the larger cranidia the spine is relatively smaller and almost vertically directed. There is variability in this respect even among cranidia of the same size. The other presumed differential characters are even less valid.

Occurrence.—Known only from conglomerate boulders at Bic. Association with olenellid fragments is conclusive proof of the Early Cambrian age of the species.

Types.—Holotype and paratype: U.S.N.M. No. 64998. Holotype of *Rimouskia spinosa:* U.S.N.M. No. 94748.

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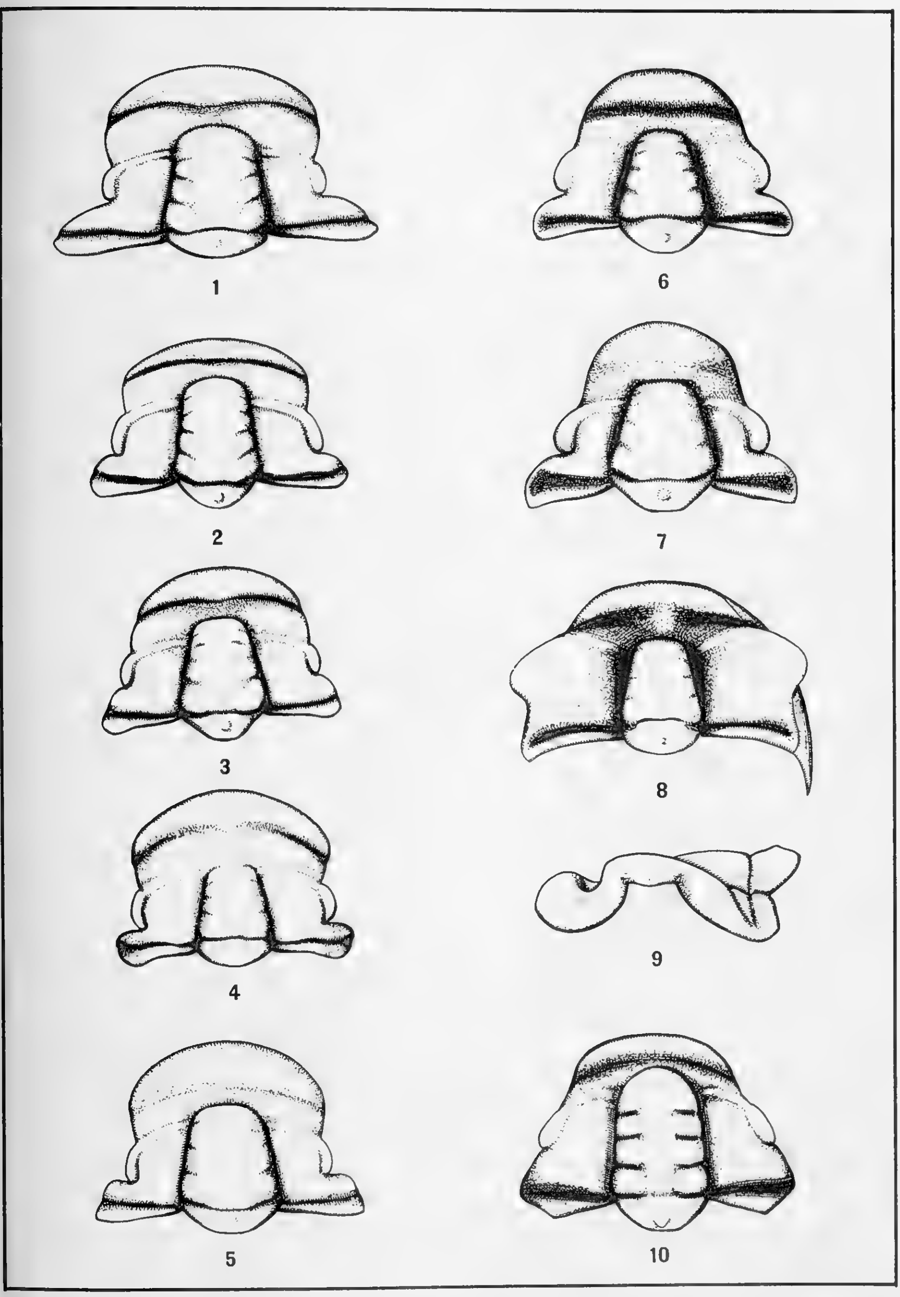
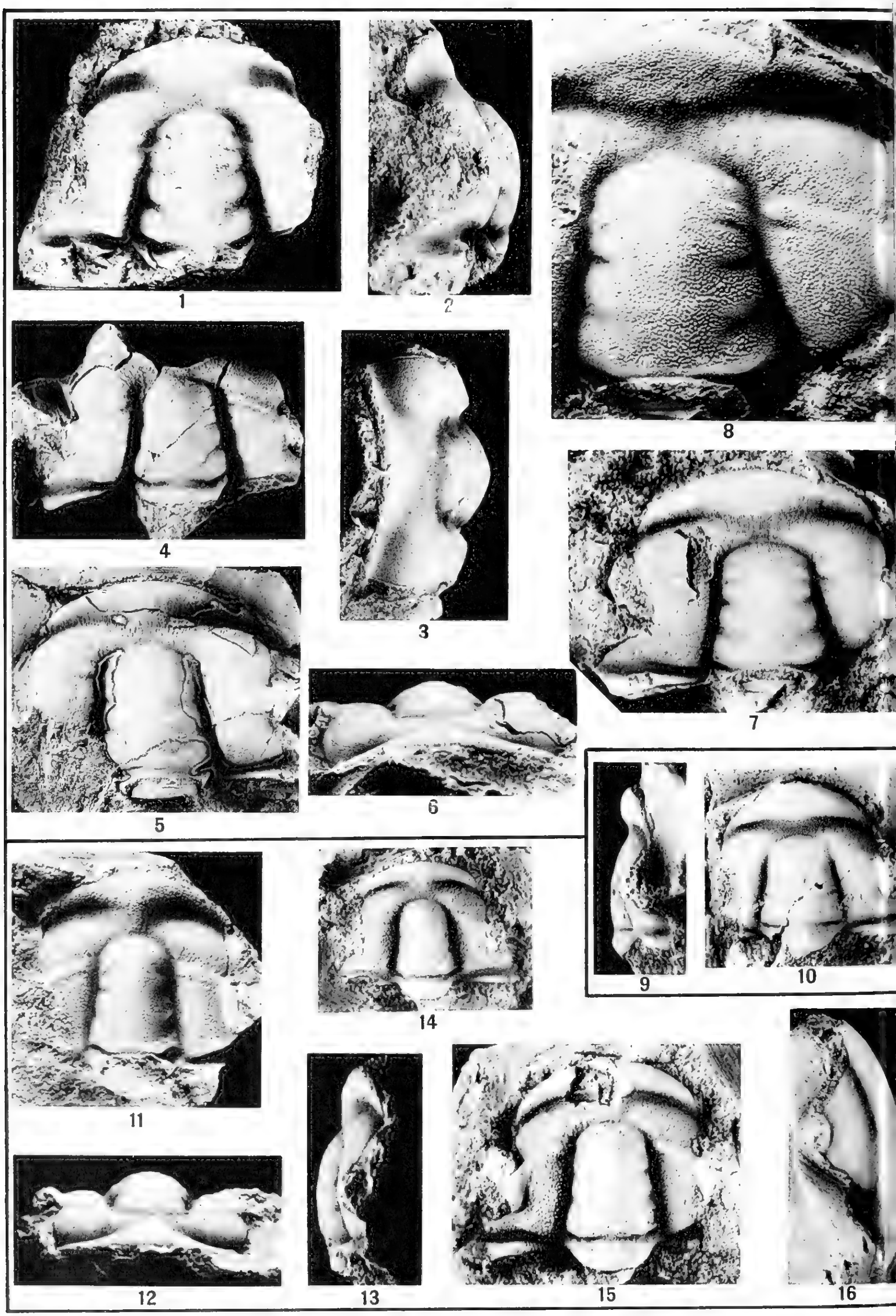


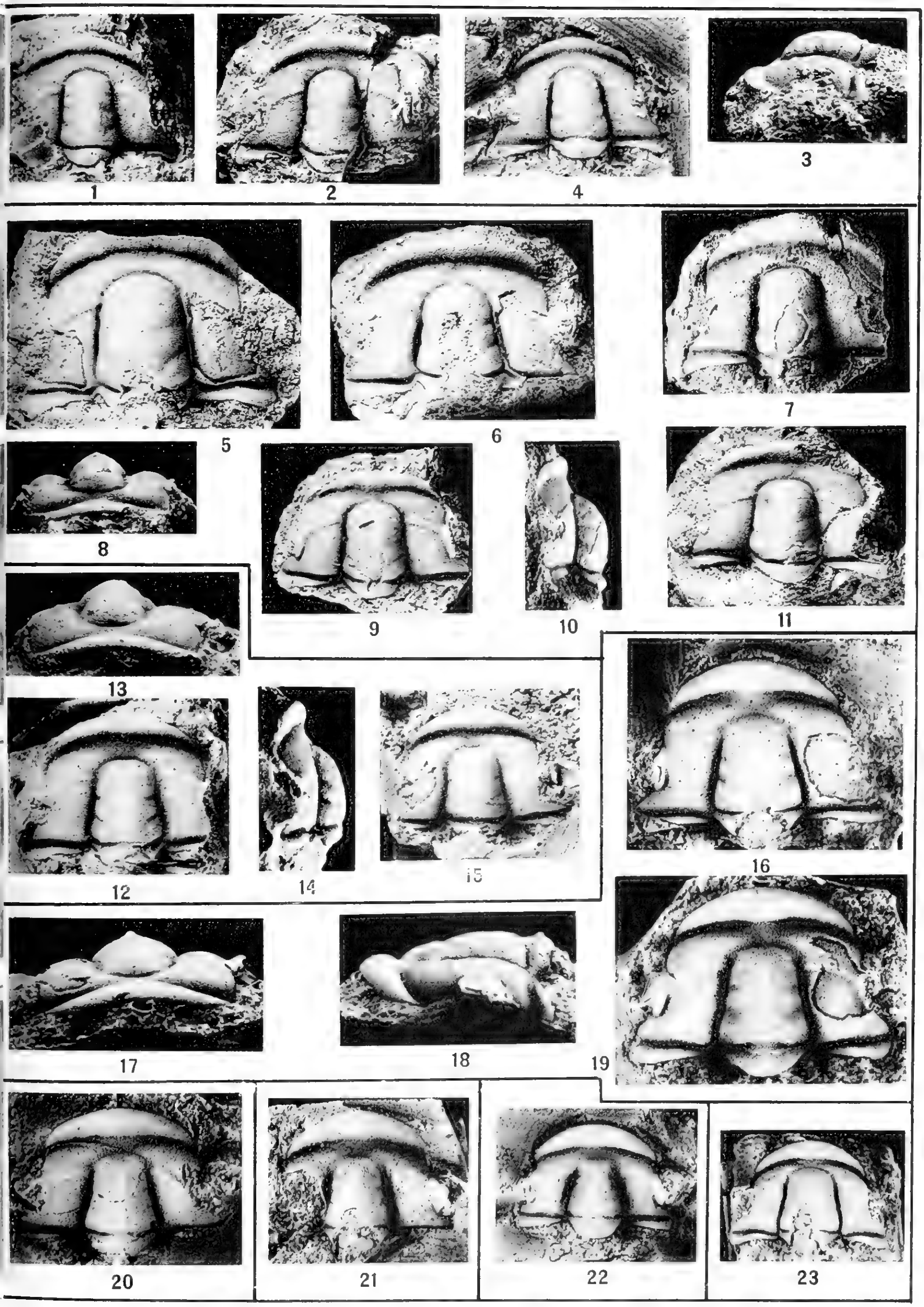
CRANIDIA OF NINE GENERA OF LOWER CAMBRIAN PTYCHOPARIID TRILOBITES

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



ANTAGMUS AND CRASSIFIMBRA

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

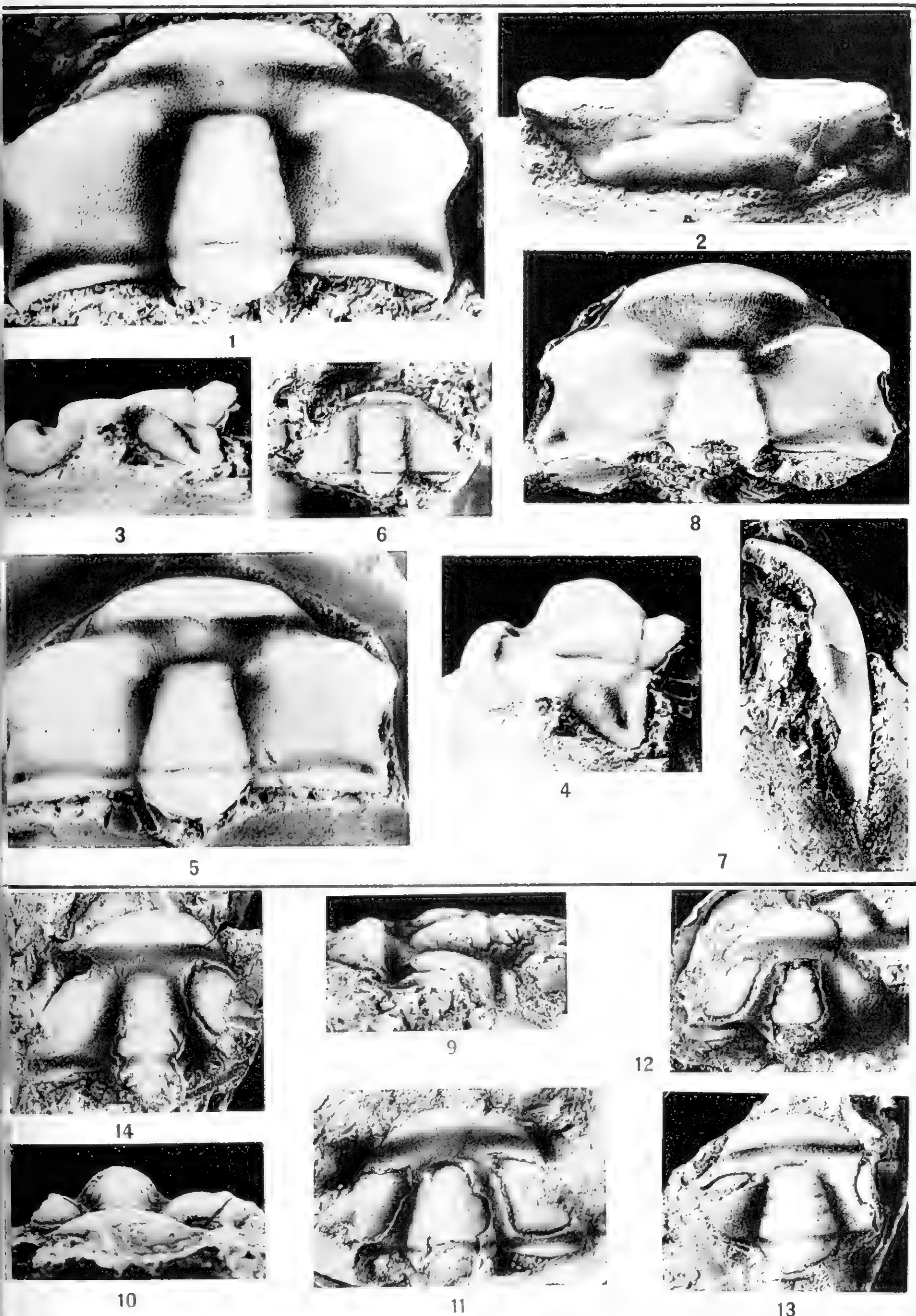


EOPTYCHOPARIA, ONCHOCEPHALUS, AND CRASSIFIMBRA

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

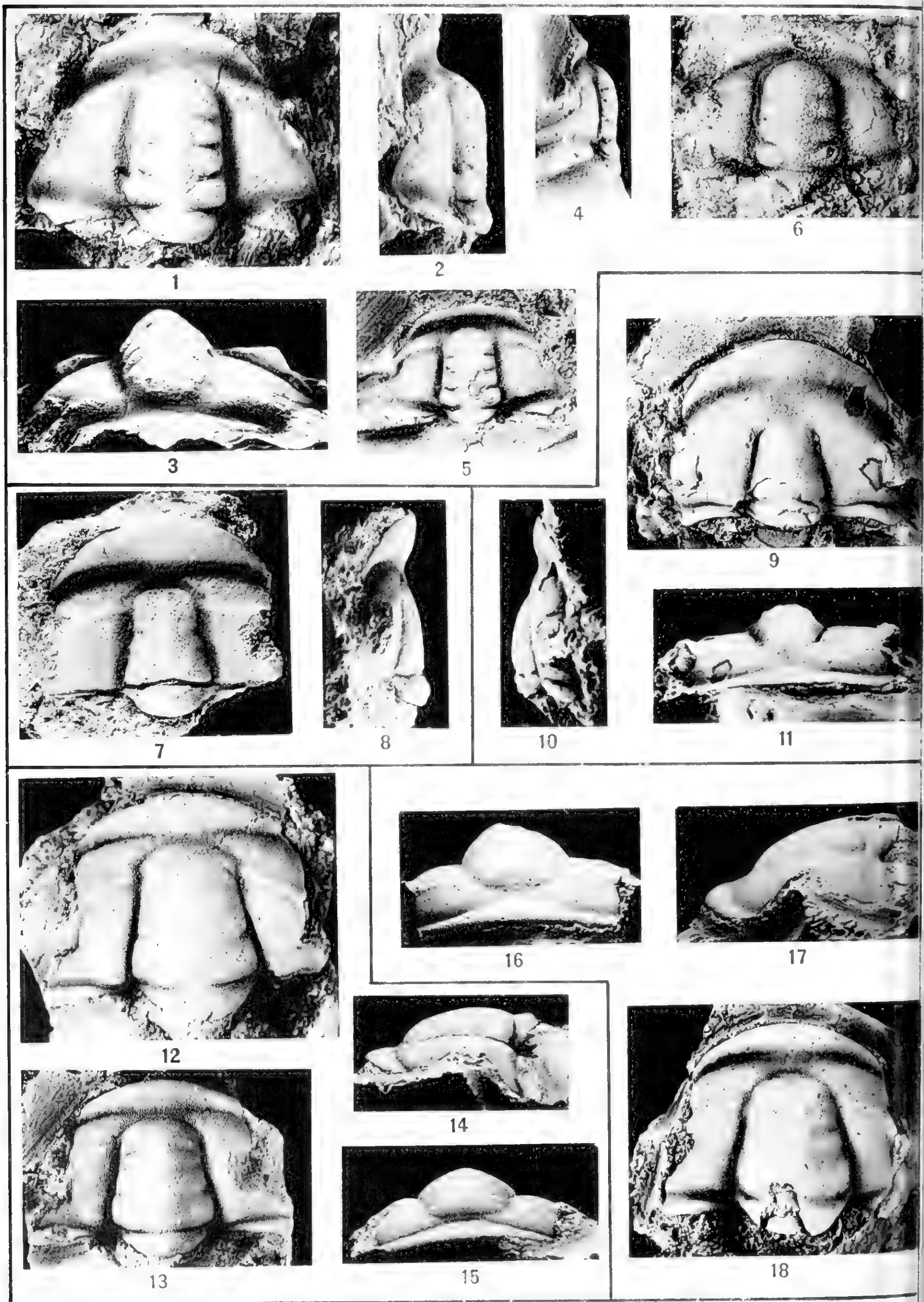
BICELLA, AUSTINVILLIA, AND PERIOMMA

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



PERIOMMELLA AND PERIOMMA

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



RIMOUSKIA, LUXELLA, AND ANTAGMUS (?)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

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A REVIEW OF THE UPPER EOCENE ARTIODACTYLA OF NORTH AMERICA

(With 18 Plates)

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INTRODUCTION

Perhaps the most significant feature of life during upper Eocene time in North America is the striking diversity and relative abundance of the Artiodactyla among the mammalian groups. At this time the even-toed ungulates made their first bid for a dominant role in the Tertiary sequence. Their new prominence is in marked contrast to the insignificant position occupied in the preceding middle Eocene Bridgerian interval, during which the Perissodactyla appear to have been unchallenged as the predominating ungulates. The reason for this new deployment is not immediately evident, but it may be described as a noticeable and perhaps rapid diversification of the bunodont types in situ together with the sudden appearance, possibly through migration, of a host of selenodont types. Remains of the latter exhibit a basic resemblance throughout but are already clearly divisible into several of the major groups, such as the hypertragulids, agriochoerids, camelids, and leptomerycids. Explanation for such a marked shift in the proportions of the fauna may lie in environmental changes that were taking place, as indicated in part by the dwindling and disappearance of the extensive lake system which provided the Green River formation. Perhaps it was a setting of the stage causing or permitting a faunal readjustment, encouraging the introduction of new types through migration.

In somewhat greater detail the changes that were accomplished following Bridgerian time include the development and expansion of the homacodont dichobunids into the genera *Bunomeryx, Hylomeryx, Mesomeryx, Pentacemylus,* and *Mytonomeryx*. The helohyids exhibit

striking growth with transition to forms such as *Achaenodon,* and may also have given rise to the Oligocene entelodonts, possibly through the long-snouted *Lophiohyus.* Included in the helohyid line is the closely related *Parahyus,* now generally and probably erroneously attributed to the lower Eocene. The selenodont forms appear in the North American upper Eocene represented by at least five families. These include the hypertragulid, *Simimeryx;* the agriochoerids, *Protoreodon* and *Diplobunops;* two distinctive groups hitherto admitted together in the Camelidae, including on the one hand the poëbrotherine camelid, *Poëbrodon,* and on the other the oromerycids, *Oromeryx, Protylopus, Camelodon,* and *Malaquiferus;* and the leptomerycids, *Leptotragulus, Leptoreodon,* and *Poabromylus. Protoreodon* is by all odds the most frequently encountered and most abundantly represented in collections. In lesser numbers, but not uncommon, are *Protylopus, Leptotragulus,* and *Pentacemylus.*

Interest in the upper Eocene artiodactyls was stimulated by an exceptionally good representation of these forms obtained by the Smithsonian Institution in 1938 from the upper or "C" horizon of the Uinta formation. The bulk of the material came from a single quarry in Myton pocket, approximately 7 miles east of the town of Myton in the Uinta Basin of northeastern Utah. During routine identification of these specimens for purposes of cataloging, it became evident that there was marked taxonomic confusion and that the systematic arrangement applied to the artiodactyls of this age was in much need of revision.

It may be noted that this study is based for the most part on dental characters, so that it may be looked upon as essentially an odontographic revision. Other details of skeletal anatomy are, of course, extremely important to a better understanding of relationships, but only a few of the forms involved were represented by anywhere near adequate skeletal material so that the additional information obtained of these could not be fully utilized on a comparative basis. A detailed investigation of the skeletal anatomy of the better-represented forms might well form the basis of a separate study, and was indeed planned by Scott[1] (see 1945, pp. 233 and 236).

ACKNOWLEDGMENTS

This review has been aided immeasurably by the courtesies extended by various museums and universities in permitting me to borrow for

[1] A study of the Uinta fauna as a whole was under way by Professor Scott at the time of his death, and considerable manuscript had been prepared.

study type and certain other specimens of upper Eocene artiodactyls. It was also thus possible to make direct comparisons and correctly identify the rather large collection of Uinta C artiodactyls in the U. S. National Museum.

Through the courtesy of Dr. Joseph T. Gregory the Uinta artiodactyls described by Marsh were made available. Drs. George G. Simpson and Edwin H. Colbert kindly permitted me to study various specimens in the American Museum collections described by Osborn, Granger, Scott, and Wortman. Materials described by Scott, or by Scott and Osborn, as well as more recently acquired collections at Princeton University were turned over to me for this investigation by Dr. Glenn L. Jepsen. Pertinent materials in the large upper Eocene collections at the Carnegie Museum were lent through the kindness of Dr. J. LeRoy Kay, these being essentially the specimens studied by Peterson.

The photographs used in plates 1-3, 6-7, and 13-18 were made through the kindness of Dr. G. Arthur Cooper, with a background overlay prepared by William D. Crockett. Those in plates 4, 5, and 8-12 were made by the photographic laboratory of the Smithsonian Institution. Charts 1 and 2 were prepared by Lawrence B. Isham, staff artist for the department of geology. Acknowledgment is also due the Committee on "Nomenclature and Correlation of the North American Continental Tertiary" of the Society of Vertebrate Paleontology for use of terms and composition of ages and subages of the Eocene employed in the charts. These are to be defined in the committee's forthcoming report.

HISTORY OF INVESTIGATION

Undoubtedly the earliest exploratory work in the upper Eocene of North America was Marsh's trip of 1870, which resulted in the discovery of fossil remains in the now well-known Uinta formation in northeastern Utah. Marsh gave the name Uinta Basin to this area of Eocene deposition, and from it the designation Uinta was subsequently applied to the beds that, overlying the Green River formation, are well exposed throughout the basin. Materials from here, collected by Marsh in 1870 and by his parties in following years, particularly 1874 and 1877, included the Artiodactyla that he referred to by the generic names *Eomeryx, Parameryx,* and *Oromeryx* in a lecture delivered and published in 1877. Inasmuch as the descriptions were inadequate, without figures, and no types were designated, the names were invalid. However, in 1894 he described and figured species of each, adding *Hyomeryx* to the list.

Cope apparently did no collecting in the Uinta Basin but may have been the first following Hayden's exploration to investigate the upper Eocene of the Washakie Basin, although Marsh was likewise prompt in getting into this area, supporting collecting parties here for several seasons. In 1872 Cope obtained the Washakie specimen that in 1873 he described as *Achaenodon insolens*. *Achaenodon* was thus the first artiodactyl named from the upper Eocene and, for that matter, the first mammal known from this horizon in North America.

Early investigations by Princeton University were conducted in the Washakie Basin in 1878 by Osborn and others under the leadership of J. B. McMaster. Material from upper or B horizon included the skull and mandible that Osborn in 1883 described as *Achaenodon robustus*. In 1886, led by Francis Speir, Princeton extended its explorations to the Uinta Basin and the collection obtained at that time formed the basis for the 1887 preliminary report by Scott and Osborn, followed by their memoir of 1889. The original descriptions of *Protoreodon* and *Leptotragulus* are a part of the preliminary report, but these forms are more fully described and figured in the memoir. Princeton continued its fieldwork in the Uinta Basin in 1895, at which time Hatcher succeeded in obtaining much of the excellent material Scott described in his preliminary (1898) and final (1899) reports on the selenodont artiodactyls of the Uinta beds. In the preliminary note Scott, evidently hurried, named *Camelomeryx* and *Merycodesmus,* both later found to be synonyms of *Leptoreodon,* and gave the preoccupied name *Agriotherium* to one of his species of *Protoreodon*. Much of this was corrected in the comprehensive 1899 report, and his interpretations were further aided by Wortman's camelid study (see below), although he disagreed with Wortman in certain details. In the later study Scott also included descriptions as new of the genus *Protagriochoerus* and the species *Protoreodon minor*.

Peterson's activity in the Uinta Basin dates from 1893 when he initiated the American Museum's field investigation of this upper Eocene occurrence; however, it was not until 1894 that significant collections were made. Specimens obtained during the latter year were described by Osborn in 1895 and among the forms recognized was a species of *Achaenodon* which he named *Protelotherium uintensis,* regarding it as an elothere. Peterson's collection also furnished the specimens described in the Eocene part of Wortman's 1898 paper on the extinct camelids. In this work Wortman named *Bunomeryx* and *Leptoreodon* as well as the oromerycid *Protylopus,* and added in-

formation on *Leptotragulus* which he considered as a synonym of the invalid *Parameryx*.

In the same year (1893) that Peterson first visited the Uinta Basin, the American Museum had Wortman collecting in the Washakie Basin. Wortman's work here was carried on further in 1895, and then in 1906 Granger, accompanied by Osborn, renewed investigation of these beds. The later Washakie expeditions, however, do not appear to have contributed significantly to our understanding of upper Eocene artiodactyls.

Undoubtedly the most intensive exploration work in the Uinta was that of later years by the Carnegie Museum, and Peterson's 1919 study of the fauna was essentially the result of Douglass' collecting in 1908 and 1909, and of his own in 1912. In this contribution Peterson added *Hylomeryx, Sphenomeryx,* and *Mesomeryx* to Wortman's *Bunomeryx,* as representing the homacodonts, and described the large agriochoerid *Diplobunops,* which from foot structure he believed to be related to the European *Diplobune.* New species also were added to *Protoreodon, Protylopus,* and *Leptotragulus.* Subsequent exploration for the Carnegie Museum in the Uinta Basin over a number of years has included particularly the collecting of J. LeRoy Kay and John Clark as well as Peterson, and in 1929 resulted in discovery of fossil materials in the relatively barren upper portion of the Uinta sequence. The collections of 1929-1931 from these upper beds were described by Peterson in 1931 as Oligocene in age, and the upper red facies was named the Duchesne formation, later corrected to Duchesne River as the earlier name was found to be preoccupied. At this time Peterson named the homacodont *Pentacemylus* and the leptotragulid *Poabromylus,* believing that the latter was a camelid. In a separate paper that year he added *Diplobunops uintensis* and *Diplobunops ultimus* to the growing list of agriochoerids from the Uinta beds. Peterson's last study of the upper Eocene, which appeared in 1934 as a posthumous paper, was largely concerned with the Duchesne River artiodactyls and included descriptions of *Mesagriochoerus primus, Leptomeryx*(?) *minutus,* and an unnamed species of *Helohyus,* all three of which I am inclined to regard as incorrectly allocated.

A final and detailed summary of the Duchesne River fauna was made by Scott in 1945, and in this he largely retained Peterson's identifications and taxonomic arrangement. Scott, like Peterson, believed the age of these beds to be Oligocene, a conclusion not generally accepted by contemporary and later workers. Unfortunately, for a proper understanding of the sequence and age relationships of the forms involved, Scott listed as in a single fauna all the forms involved

in the study, and it is noted that such forms as, for example, *Camelodon arapahovius,* and possibly others known to be from the Uinta equivalent in the Beaver Divide area, are included with Randlett *"Mesagriochoerus" primus,* Lapoint *Poabromylus kayi,* and *Leptomeryx*(?) *minutus* (this is *Simimeryx*), together with Oligocene *Brachyhyops wyomingensis.*

Various institutions have paid visits to the Uinta and Washakie Basins in late years, and mention may be made of that conducted by the writer for the Smithsonian Institution in 1938 which led to the present study. We were indeed fortunate in locating a site which produced an excellent series of specimens representing the smaller Artiodactyla of the Myton or C horizon. The work of Princeton University in recent years has been referred to, and a collection obtained by a group from Harvard University in 1940 was also made available for this study, but unfortunately much of the latter material has yet to be prepared.

GEOGRAPHIC AND GEOLOGIC OCCURRENCE

There are essentially but five general areas where mammal-bearing deposits of upper Eocene age are exposed, and all these have produced notable fossil remains of Artiodactyla. Listed in order of importance, they are the Uinta Basin in northeastern Utah, the Washakie Basin in southern Wyoming and adjacent Colorado, the Wind River Basin in central Wyoming, the area in which the Sespe formation is distributed in southern California, and Sage Creek, Montana. By far the most significant area, and that from which remains of most of the known forms have been obtained, is the Uinta Basin. It is here that we have the most nearly complete stratigraphic sequence known for the continental upper Eocene, a sequence that is used rather generally as a standard of reference for studies elsewhere. Two formations are recognized, the lower or Uinta, interfingering below with the Green River beds, and the upper or Duchesne River, based essentially on a facies change from that of the Uinta resulting from a change in source of sediments. Laterally, this facies change transgresses time boundaries, and hence cannot be relied on as limiting horizons or ages except in closely adjacent sections. The Uinta formation is divided into three parts lettered A to C; or into two parts: Wagonhound, including A and B, and Myton, comprising C. The Duchesne River or red facies has been likewise divided into three members. Kay has named these Randlett, Halfway, and Lapoint in ascending order. Remains of Artiodactyla have been obtained from all except Uinta A, with the bulk of the material coming from B and

C. Occurrences in the Duchesne River formation, however, are exceedingly rare.

In the Washakie Basin the upper or B portion of the Washakie formation is regarded as upper Eocene and generally considered to be about equivalent in age to the Wagonhound or lower part of the Uinta formation. So far the only artiodactyl remains known to have been found in the Washakie beds are of *Achaenodon,* a questionable *Protylopus,* and *Homacodon.* The *Achaenodon* and (?)*Protylopus* specimens are from Washakie B, whereas *Homacodon* is from Washakie A, according to Granger (1909). In addition to these, *Parahyus vagus,* as will be discussed in the systematic treatment of the species, was based on a specimen that almost certainly came from the Washakie, and likely from a horizon nearly transitional between A and B.

The occurrence of upper Eocene strata in the Wind River Basin is divided between a narrow zone along the north side of the basin and the Beaver Divide forming the rim to the south. To the north, particularly along the south side of Badwater Creek, remains have been obtained of a variety of artiodactyls, including a homacodont, possibly *Pentacemylus,* leptotragulids, and oromerycids, as well as *Protoreodon* and *Diplobunops.* Somewhat farther west near Dry Creek the oromerycid *Malaquiferus* was discovered. As far as can be determined from the fauna as a whole, these Artiodactyla are upper Uintan in age, probably Uinta C, rather than Duchesnean.

Much confusion exists as to the relative ages of horizons represented in the sequence exposed along the Beaver Divide at the southern rim of the Wind River Basin. Uintan beds here have produced *Camelodon arapahovius* and probably several of the specimens of uncertain locality which have been attributed to the Beaver Divide conglomerate. The top of the Uintan sequence is deeply channeled, and the fill has produced remains of Oligocene age. At least one of these, the *Brachyhyops wyomingensis* skull, was described as coming from the uppermost part of the Uintan sequence. I am informed by Dr. Franklyn B. Van Houten [2] that the Beaver Divide conglomerate overlies the channel fill and so is likewise Oligocene in age. The materials of Eocene aspect attributed to the Beaver Divide conglomerate are for the most part uncertain as to locality, particularly the immature specimen described by Scott as *Mesagriochoerus primus,* collected by a local resident. The type of *Protoreodon tardus* was found by J. LeRoy Kay but this is a relatively early protoreodont, presumably not as late as Duchesnean and surely not later than Eocene. For an ex-

[2] Personal communication.

planation, appeal is made to the highly disconformable relationship between Eocene and Oligocene strata. An immature-jaw fragment collected by Van Houten from beds undoubtedly a part of the Beaver Divide conglomerate resembles *Protoreodon,* but the two lower teeth preserved are not truly diagnostic so that a small species of *Agriochoerus* may well be represented. It would seem, from a review of the Beaver Divide materials and occurrences, and from field information furnished me by Van Houten and others, that the Duchesnean interval is not represented by sediments in the Beaver Divide. The hiatus in time is further indicated by the marked disconformity.

A portion of the Sespe formation as exposed to the north of Simi Valley in southern California has been demonstrated by Stock to include strata of at least two horizons of upper Eocene age. The lower of these, as represented by locality 180, also known as Tapo Ranch, produced *Leptoreodon* (*Hesperomeryx*) *edwardsi* and is about equivalent to Uinta C. Significantly higher and possibly equal to Lapoint in age, locality 150 produced the remains of *Simimeryx hudsoni.* No Artiodactyla are known from the earlier Poway conglomerate in San Diego County.

The Eocene on Sage Creek in western Montana, I am informed by H. E. Wood II,[3] is surely Uintan. The collections from here, now in the Carnegie Museum, contain protoreodont remains.

ENVIRONMENT

Certain rather general conclusions seem evident regarding the environment that existed during upper Eocene time in the portion of the Rocky Mountain region in which much of our upper Eocene fossil material has been obtained. Perhaps the most significant information forthcoming is derived from the changing lithology observed in the upper Eocene sequence of the Uinta Basin. This pertains to the transition from the lake deposits of the Green River formation, as represented in Utah, to the predominantly greenish-gray sediments of the Uinta formation. The transition is not abrupt, but there is an interfingering between the fluviatile or flood plain sediments with the deltaic and lacustrine sediments, denoting a periodic retreat of the lake and an overall reduction and eventual disappearance. Furthermore, the upper part of the Uinta formation intergrades laterally and is superseded by a red facies, the Duchesne River formation, which owes its origin to a transgression of sediments from a different source.[4]

[3] Oral communication.

[4] I am much indebted to Dr. John Clark for an understanding of upper Eocene sedimentation in the Uinta basin.

The overall picture would appear to be one of increasing aridity and one in which there was surely a floristic change effecting the proportions of the various elements that go to make up the food supply of herbivorous groups. Whether this change was a causative factor in a transition in place to a more-selenodont type of dentition in several of the artiodactyl groups represented, or whether the environmental change permitted a faunal readjustment through migration, has not been determined. Nevertheless, there is a correlation between these facts which must be regarded as more than casual.

While there is similar evidence of increasing aridity in a change from lacustrine to fluviatile deposition in the Washakie Basin during Eocene time, this change seems to have occurred somewhat earlier, as the Green River lake there evidently disappeared during the middle Eocene. In the Wind River Basin, on the other hand, although the middle and upper Eocene sequence has rather limited surface distribution, there would appear, nevertheless, to be no evidence of a lake accumulation comparable to that of the Green River formation. Presumably, however, the climatic change indicated for the Uinta Basin was of more than local importance.

Faunally, not only was there a shift to more-selenodont types among the Artiodactyla but, as has already been noted, the Artiodactyla, extremely rare in the middle Eocene, have nearly or quite supplanted the Perissodactyla as the more-populous ungulates in the fauna. Associated with the artiodactyls were a rather marked diversity of titanotheres, various rhinos, tapiroids, and horses of the genus *Epihippus* among the perissodactyls; waning groups of creodonts, together with miacid forerunners of modern carnivores; a rather notable assemblage of sciuromorph rodents; and, interestingly enough, the first North American lagomorphs.

RELATIONSHIPS

Undoubtedly one of the more interesting aspects of this study has been the attempt to determine the relationships between the various kinds of artiodactyls that lived during Eocene time; to try to visualize something of the phylogenetic arrangement, and relate, where possible, their phyletic groupings to the better-known families of the Oligocene. Heretofore, almost no attempt has been made to demonstrate these relationships on any tangible basis and show pictorially the conclusions obtained. Wortman called attention to the camel-like features of *Protylopus,* and, noting the striking resemblances between the various Eocene forms, regarded most of them as camelid. Scott made an outstanding contribution in his report on the selenodont

artiodactyls of the Uinta, but I find difficulty in accepting many of his conclusions as to relationships, particularly as portrayed in the rather abbreviated synoptic chart given in this work. As far as the bunodont artiodactyls are concerned there appears to have been no previous attempt at ciphering origins and sequence, although much of the groundwork for this was laid by Sinclair and Peterson.

Treating first the bunodont forms, I believe these may be logically regarded as representing a single rather large family, the Dichobunidae. There would appear to be justification for including the North American forms with those of Europe, although distinct directions and tendencies are noted, inasmuch as basic resemblances are evident suggesting a not too remote common ancestry, possibly in early Eocene or late Paleocene time. It is interesting to note, however, that the schism between the Old World and New World groups appears to have widened with advance in Eocene time, and I see no certain evidence of a later interplay between the hemispheres within the period.

While including the Eocene bunodonts within the Dichobunidae there are, nevertheless, cogent reasons for recognizing at least three subfamilies among the North American forms, as may be seen in the accompanying chart. The genus *Eohyus* (Marsh, 1894) is omitted from consideration in this study, as I am unable to determine its relationships or add any information to that brought forth by Sinclair (1914, p. 267), since the type materials are so very incomplete. These are from the lower Eocene (or Paleocene?) of New Mexico.

An early group, and one which I regard as fundamentally distinct, includes *Diacodexis, Wasatchia,* and *Bunophorus.* These are separated under the subfamily Diacodexinae. *Wasatchia* and the closely related *Bunophorus* may not much resemble *Diacodexis,* with their much more inflated tooth cusps, but basically their dental structures are rather similar and together seem rather more condylarth-like than other dichobunids. There is no record of any diacodexids after Lost Cabin time but the suggestion is made that the leptochoerids may have originated somewhere in this subfamily. If the leptochoerids are of North American origin, which I am rather inclined to believe, then of the various dichobunids known here, only the diacodexids on the basis of dentition would seem to qualify (not the helohyids as suggested by Scott, 1940, p. 378). Except for relative proportions of the teeth, one cannot escape noticing the basic similarity of the molars. The premolars, moreover, though not so enlarged or so elongate (except in advanced *D. secans*), would seem potentially qualified, particularly those of the upper dentition. In view of the long interval

for which there is no supporting record, this suggestion may seem highly speculative but the resemblance must be more than coincidence.

In conflict with the foregoing hypothesis attention should be called to the reduction of the lateral toes of the hind foot to slender vestiges in certain material of *Diacodexis,* a condition that led Matthew to believe that *Diacodexis* could not be ancestral to any of the later Artiodactyla. However, the extent to which this condition may be variable in the *Diacodexis* complex, in view of the much better developed lateral digits of the fore foot, is not known, and *Diacodexis* certainly shows striking variability in its dentition. Moreover, the hind-foot structure of *Leptochoerus* seems obscure since Scott, as late as 1945, referred to Marsh's statement that in a Yale specimen, "The hind foot resembles that of *Homacodon,* having four usable digits, but the navicular and cuboid are co-ossified, an unexpected feature."

The second dichobunid subfamily group, for which the name Homacodontinae is retained, was certainly not derived from *Diacodexis* or the Diacodexinae. The Wasatchian form *Hexacodus,* which has for its counterpart *Protodichobune* from the lower Eocene of d'Epernay, France, would appear to have been more nearly in the line of descent for later typical homacodonts but was evidently off to one side and, though much less specialized in the dental peculiarities characterizing *Antiacodon,* may well have given rise to that Bridgerian genus. Nevertheless, it is worth noting that within the upper Wasatchian material of *Hexacodus* a certain variant in the dental pattern is strikingly suggestive of *Microsus. Microsus* and *Homacodon* are rather alike although the former has teeth with cusps that appear to be more acute. The teeth of *Microsus* are of more delicate and perhaps more primitive appearance and potentially better suited to the ancestral position with respect to the upper Eocene homacodonts than is the large *Homacodon vagans.* Unlike *Homacodon,* the fourth lower premolar of *Microsus* has a pronounced metaconid, but this does not preclude a relationship suggested by the chart.

By upper Eocene time the homacodonts, though still essentially bunodont, had acquired rather marked styles on the outer sides of the upper teeth, and the outer cusps of the lower molars had become a little more crescentic. In one line, represented by *Bunomeryx* and later *Pentacemylus,* the hypocone was early lost and a mesostyle early gained in the upper molars. *Mytonomeryx* is apparently related but was derived from the stock before the hypocone became reduced. It further specialized in a lengthening of the snout. *Hylomeryx* likewise retained the hypocone but did not achieve a mesostyle. As a remain-

ing possibility in the combination of characters, *Mesomeryx* early lost the hypocone but did not develop a mesostyle. In *Mesomeryx,* like *Hylomeryx,* however, a suggested tendency is noted toward the formation of a protoloph at the expense of the protoconule.

As will be discussed in somewhat greater detail in the systematic portion of this paper, there would appear to be some justification for regarding *Simimeryx* and the hypertragulids as derived from the homacodonts at some point near *Mesomeryx.* There is, however, a peculiar resemblance, which probably should not be disregarded, of upper and lower molars of *Simimeryx* to the agriochoerids. It is perhaps a similar step in the transition of each from the bunodont to the more-selenodont pattern, so that the change from a bunodont homacodont, such as *Mesomeryx* to *Hypertragulus,* included the *Simimeryx* stage; possibly equivalent to *Protoreodon petersoni* in its suspected relationship to the Oligocene merycoidodonts. Attention is likewise called to the very divergent origins indicated for hypertragulids and leptomerycids. Regardless of an apparent modification toward a similar mode of existence, they show striking dissimilarities in details of dentition. Retaining these in the same family, as pointed out elsewhere, is untenable in view of the polyphyletic origin indicated.

A third subfamily of dichobunids, the Helohyinae, is represented by what appears to be a nearly continuous sequence from *Helohyus* to *Achaenodon.* The surprising increase in size is foreshadowed in *Helohyus lentus* of Bridger D, and the interval between *Helohyus* and *Achaenodon* is nicely bridged both in size and tooth characters by *Parahyus vagus,* the type of which is almost certainly from the Washakie beds. A simplicity of premolars is evident throughout, possibly with the loss of one between *Helohyus* and *Parahyus.* The bunodont character of the *Helohyus* molars is further emphasized and simplified in *Achaenodon* with the reduction of the protoconule and loss of the vestige of a hypocone in upper teeth of *Achaenodon* and with the loss of the paraconid (vestigial in M_1 of *Parahyus*) and hypoconulid (except M_3) in the lower molars. *Helohyus* would appear to be most like *Homacodon* of the various homacodonts in the simplicity of the premolars, but is unlike *Homacodon* in the near absence of a hypocone in the upper molars and the presence of a paraconid in the lowers. The Helohyinae might well have had roots converging with those of *Homacodon* before loss of the paraconid and the development of so prominent a hypocone in the latter. The early helohyids are perhaps structurally intermediate between diacodexids and homacodonts.

The entelodonts were not, of course, derived from *Achaenodon,*

as the directions taken in dental specialization, though similar as to adaptation, are entirely different in detail. Both are large bunodont forms, but in *Archaeotherium* the snout is very elongate, all the premolars are retained, and the secondary cuspules, lost or reduced in *Achaenodon,* are as much emphasized as the primary cusps. If *Archaeotherium* is related to the Helohyinae, it is through an earlier form, possibly *Lophiohyus,* possessing a dental structure and formula that had not gone too far in the direction of *Achaenodon.* I suggest *Lophiohyus* only because this form had already developed an elongate snout. Its dentition is very much like that of *Helohyus.*

The Tayassuidae is shown in the chart, not because of any particular conclusions as to origin in the dichobunids, but because it might well have been derived from North American forms. However, in this instance, the European cebochoerids must not be overlooked as potential ancestors. Its origin may lie somewhere in the middle Eocene homacodonts rather than in the helohyids as suggested by Pearson, inasmuch as the posterointernal cusp of the upper molars in *Perchoerus,* unlike *Helohyus,* would appear to be the hypocone, and as the metaconule is much reduced—that is, unless the small cusp in the position of a metaconule in *Perchoerus* was newly acquired and not the original metaconule.

Directing our attention to the selenodont families, we find the agriochoerids and oromerycids, though with highly crescentic appearing molars, somewhat intermediate between the dichobunids on the one hand and the leptomerycids and poëbrotherine camelids on the other, in the perhaps retarded or differently developed protocone above and hypoconid below. For the agriochoerids I have shown a rather simplified version of their relationship in the general chart, but their lineage within upper Eocene time may have been somewhat more complex in detail, as suggested in chart 2 (p. 67). I do not believe that more than two genera are represented, but within *Protoreodon* there appears to have been at least two distinct sequences of species or mutants that can be carried from middle through upper Uinta levels. The larger of these was evidently derived from or was close to *P. parvus* and carried through Uinta C as *P. pumilus,* culminating in *P. pumilus annectens.* This may well be the line that gave rise to *Agriochoerus.* A sequence of smaller forms can be recognized in *P. minor* of lower Uinta C, culminating in *P. petersoni* in upper Uinta C. If *Merycoidodon* was derived from any of the known forms of *Protoreodon,* the line represented by *P. petersoni* is surely the most likely source. Nevertheless, this is an agriochoerid that cannot be

separated even generically from the complex that includes the large *Protoreodon pumilus annectens.*

Diplobunops, the larger of the two Eocene agriochoerids, has much enlarged and widely separated caniniform teeth but is further characterized by cheek teeth rather more primitive appearing than in contemporary protoreodonts. As an aberrant line *Diplobunops* would appear to have separated from *Protoreodon* not much earlier than lower Uinta time, or possibly even as late as Uinta B. It is known only from Uinta B, C, and Randlett horizons.

Removed from inclusion with the poëbrotherines, in the Camelidae, are a group of genera closely related to the Chadronian *Eotylopus,* here distinguished as the new family Oromerycidae. Their camelid resemblances, I believe, are largely adaptive, as differences in molar tooth structure from that in the poëbrotherines seem fundamental and indicative of a rather remote differentiation, suggesting a heretofore unnatural family grouping. I find no close relationship indicated between the oromerycids and any of the other families, and their origin in the bunodont forms, while uncertain in position, may have been quite independent of other selenodonts. *Eotylopus* is evidently the last of the line.

The poëbrotherine forms, like the leptotragulids, show early acquisition of a distinctly selenodont tooth structure, suggesting perhaps a closer relationship with the latter group than with oromerycids, although this is not demonstrated, inasmuch as the early development of P_1 as a caniniform tooth in the leptotragulids is a significant difference. In the absence of any distinctive lower caniniform tooth the poëbrotherines are most like the Eocene oromerycids; however, this also characterizes the homacodonts. Although like others of the upper Eocene selenodonts in having obscure pre-upper Eocene antecedents, the poëbrotherines nevertheless distinguished themselves by the well-documented diversity and geologic longevity of their descendant forms.

The Leptomerycidae as represented by the leptotragulids would, together with the poëbrotherines, appear to be the most advanced and specialized in the attainment of crescentic or selenodont molars among the upper Eocene forms. The Oligocene forms were surely derived from the leptotragulines, but it is not clear that either *Leptoreodon* or *Leptotragulus* gave rise to *Leptomeryx.* Its origin may have been from an intermediate and perhaps earlier but closely related form. There is, however, an even better case for *Protoceras* and the Protoceratidae, and I find that *Leptotragulus,* as far as it is known, completely meets the requirements. In addition to the similar molar structure, the premolars in *Protoceras* are entirely similar to those

OLIGOCENE		
	ORELLAN	
	CHADRONIA	
EOCENE	DUCHESNEAN	Lapoin
		Halfwa
	UINTAN	Randl
		Uinta
		Uinta
		Uinta
	BRIDGERIAN	Bridg
		Bridg
		Bridg
		Bridg
	WASATCHIAN	Lostca
		Lysite
		Grayb
PALEOCENE		

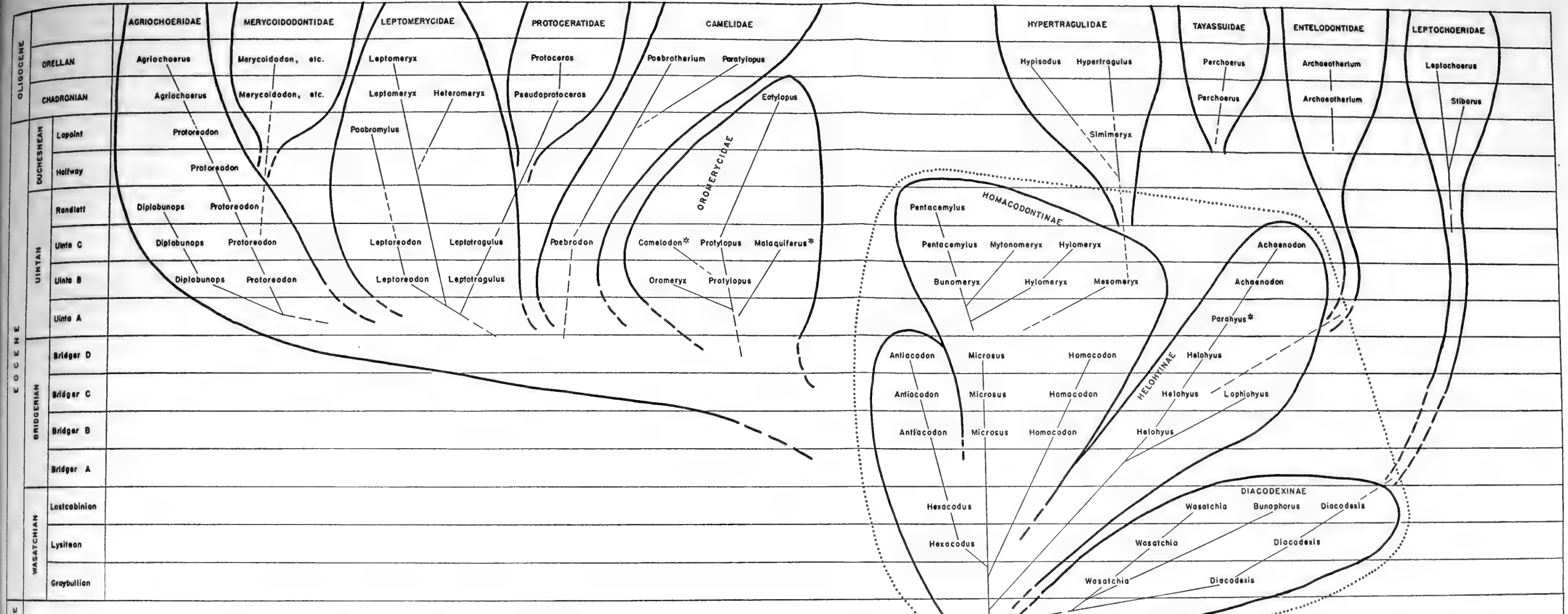

Chart No. 1

SUGGESTED PHYLOGENETIC ARRANGEMENT OF NORTH AMERICAN EOCENE ARTIODACTYLA

of *Leptotragulus*. Scott (1899) regarded *Leptoreodon* in this relationship, but the premolars in this form are rather distinctive and not like those in *Protoceras*. Instead, Scott indicated with a query that *Hypertragulus* may have come from *Leptotragulus*, but this suggestion is likewise unacceptable. It may be further noted in the chart presented here that Peterson's *Poabromylus* is removed from the Camelidae and tentatively aligned with *Leptoreodon*. This, of course, is not certain, but I am convinced from the molar structure that it is leptotraguline rather than camelid.

Reviewing the various Eocene artiodactyls of North America, with the amazing array of Old World forms in mind, one is impressed by the resemblance of certain North American groups to others in the European assemblage. The division of the dichobunids has been noted, and the similarity between early Eocene *Hexacodus* and *Protodichobune* is possibly the closest actual approach between the two major portions of the family, although these genera appear to have distinctive premolars. In the middle Eocene, *Homacodon* is rather like *Dichobune*, though with simpler premolars, and perhaps like *Mouillacitherium*, but again with simpler premolars and in addition a better-developed protoconule on the upper molars, to judge by Stehlin's (1906) excellent illustrations. Some of the earlier *Dichobune* species, however, with a weaker hypocone are more suggestive of *Helohyus*. It should be noted, moreover, that much of the European middle Eocene dichobunid material shows a precocious tendency toward selenodonty not seen in any of our Bridger forms. Furthermore, the more-distinctive selenodont groups such as the anthracotheres and anoplotheres also appear in the middle Eocene assemblages of Europe, and a comparable though independent development in North America is not seen until upper Eocene.

Although there is a rough similarity between our upper Eocene selenodonts and those of Europe, as for example between the agriochoerids and anoplotheres, or between our camelids and the xiphodonts, there are fundamental differences between these groups, and I fail to find any direct line between them or any justification for considering our selenodont stocks as derived from those of Europe. The trend toward selenodonty has surely progressed independently, in parallel though not strictly identical ways, in the two areas. More adequate information on the origin of the North American selenodont groups will possibly be revealed when faunas of Uinta A time or intermediate horizons in the Washakie are discovered. It is highly probable that no interchange of faunas took place between the two continents from about the beginning of the Eocene to its end. There is, however, as at the beginning of the Eocene, ample evidence for

faunal exchange initiating Oliogocene time, with the appearance on this side of anthracotheres, choeropotamids, and probably other forms.

CLASSIFICATION

The following is the revised classification of the upper Eocene artiodactyls as adopted in this study:

DICHOBUNIDAE Gill, 1872
  HOMACODONTINAE, Peterson, 1919
    Bunomeryx Wortman, 1898
      Bunomeryx elegans Wortman, 1898
      Bunomeryx montanus Wortman, 1898
    Hylomeryx Peterson, 1919
        Synonym: *Sphenomeryx* Peterson, 1919
      Hylomeryx annectens Peterson, 1919
      Hylomeryx quadricuspis (Peterson), 1919
    Mesomeryx Peterson, 1919
      Mesomeryx grangeri Peterson, 1919
    Pentacemylus Peterson, 1931
      Pentacemylus progressus Peterson, 1931
      Pentacemylus leotensis, new species
    Mytonomeryx, new genus
      Mytonomeryx scotti, new species
  HELOHYINAE (Marsh, 1877, as Helohyidae)
    Achaenodon Cope, 1873
        Synonym: *Protcolotherium* Osborn, 1895
      Achaenodon insolens Cope, 1873
      Achaenodon robustus Osborn, 1883
      Achaenodon uintensis Osborn, 1895
    Parahyus Marsh, 1876
      Parahyus vagus Marsh, 1876
HYPERTRAGULIDAE Cope, 1879
  HYPERTRAGULINAE Matthew, 1908
    Simimeryx Stock, 1934
      Simimeryx hudsoni Stock, 1934
      Simimeryx minutus (Peterson), 1934
AGRIOCHOERIDAE Leidy, 1869
    Protoreodon Scott and Osborn, 1887
        Synonyms: *Eomeryx* Marsh, 1894
          Hyomeryx Marsh, 1894
          Agriotherium Scott, 1898 (not Wagner, 1837)
          Chorotherium Berg, 1899
          Protagriochoerus Scott, 1899
          Mesagriochoerus Peterson, 1934
      Protoreodon pumilus (Marsh), 1875
        Synonyms: *Protagriochoerus annectens* Scott, 1899
          Protoreodon medius Peterson, 1919
          ?Protoreodon tardus Scott, 1945
      Protoreodon parvus Scott and Osborn, 1887
        Synonym: *Hyomeryx breviceps* Marsh, 1894

Protoreodon paradoxicus (Scott), 1898
Protoreodon minor Scott, 1899
Protoreodon primus (Peterson), 1934
Protoreodon petersoni, new species
Diplobunops Peterson, 1919
Diplobunops matthewi Peterson, 1919
Synonyms: *Diplobunops uintensis* Peterson, 1931
Diplobunops ultimus Peterson, 1931
Diplobunops crassus Scott, 1945
Diplobunops vanhouteni, new species
OROMERYCIDAE, new family
Oromeryx Marsh, 1894
Oromeryx plicatus Marsh, 1894
Protylopus Wortman, 1898
Protylopus petersoni Wortman, 1898
Protylopus? annectens Peterson, 1919
Camelodon Granger, 1910
Camelodon arapahovius Granger, 1910
Malaquiferus, new genus
Malaquiferus tourteloti, new species
CAMELIDAE Gray, 1821
Poëbrotheriinae Zittel, 1893
Poëbrodon, new genus
Poëbrodon kayi, new species
LEPTOMERYCIDAE Scott, 1899
Leptotragulinae Zittel, 1893
Leptotragulus Scott and Osborn, 1887
Synonym: *Parameryx* Marsh, 1894
Leptotragulus proavus Scott and Osborn, 1887
Synonyms: *Parameryx laevis* Marsh, 1894
?Parameryx sulcatus Marsh, 1894
Leptotragulus medius Peterson, 1919
Leptotragulus clarki, new species
Leptoreodon Wortman, 1898
Synonyms: *Merycodesmus* Scott, 1898
Camelomeryx Scott, 1898
Leptoreodon marshi Wortman, 1898
Synonyms: *Merycodesmus gracilis* Scott, 1898
Camelomeryx longiceps Scott, 1898
Leptoreodon (Hesperomeryx) edwardsi Stock, 1936
Poabromylus Peterson, 1931
Poabromylus kayi Peterson, 1931

In an attempt to simplify characterizations or present them in a usable form there is given on the following pages a synoptic arrangement in the form of a key, including all the recognized genera for the North American Eocene. The key is divided into two parts: First a systematic arrangement is made conforming in a general way to the classification, and following this a topical presentation is given in which the various Eocene genera and subfamilies are listed accord-

ing to compliance with cited characters. One should bear in mind that even the best of keys are essentially arbitrary and often misleading, and it is with some trepidation that the following is included in this study.

A. Cheek teeth essentially bunodont....................DICHOBUNIDAE

1. Hypoconulid of M_1 and M_2 developed from cingulum distinctly posterior to saddle between hypoconid and entoconid. P_1, C, and probably I_3 subequal as far as known.........................HOMACODONTINAE

a. Trigonid somewhat elevated and anterointernal cusp of lower molars twinned (or paraconid distinct from metaconid). P_4 with metaconid. Talonid of lower molars broadly basined.

(1) Paraconid and metaconid about equal and close together *Hexacodus*

(2) Metaconid more reduced than paraconid and crista obliqua joins higher on metaconid. Upper molars with hypocone (may be double), small cusp anterior to protocone, and small mesostyle on external cingulum..............................*Antiacodon*

b. No paraconid on lower molars, except possibly M_3. P_4 without metaconid. Cusps noncrescentic. M^1 and M^2 with parastyle but no mesostyle.

(1) Hypocone on M^1 and M^2...........................*Homacodon*

(2) No hypocone on upper molars (lower molars not known, see also 1d (2) (b))....................................*Mesomeryx*

c. Paraconid on M_1 and vestigial or absent on other lower molars. P_4 with metaconid. Cusps high and noncrescentic............*Microsus*

d. Lower molars with subcrescentic outer cusps. P_4 with metaconid.

(1) Upper molars with mesostyle and distinct protoconule.

(a) Hypocone on M^1 and M^2. Marked diastemata separating anterior premolars ....*Mytonomeryx*

(b) Hypocone on M^1 only (vestige on M^2). Short or no diastemata separating anterior premolars.....................*Bunomeryx*

(c) No hypocone on upper molars. Short or no diastemata between anterior premolars ....*Pentacemylus*

(2) Upper molars without mesostyle (or very weak). Protoconule indistinct or forming a loph with protocone.

(a) Hypocone on M^1 and M^2...........................*Hylomeryx*

(b) No hypocone on upper molars. (Lower molars not known, see also 1b (2))....................................*Mesomeryx*

2. Hypoconulid of M_1 and M_2 weak (and double) in early stages and absent in later stages. C not known in early stages but caniniform in advanced stages. P_4 without metaconid. Hypocone of upper molars vestigial or absent...HELOHYINAE

a. Four lower premolars? Paraconid distinct from metaconid. Hypoconulid of M_1 and M_2 weak and may be developed from cingulum posterior to saddle between hypoconid and entoconid, and as a second small cuspule in the saddle very close to the hypoconid.

(1) Lower premolars in close sequence.....................*Helohyus*

(2) Lower premolars separated by marked diastemata.......*Lophiohyus*

b. Three lower premolars. P_4 enlarged. Paraconid and hypoconulid (except M_3) vestigial or absent. Lower C caniniform.
(1) Molars relatively elongate............................... *Parahyus*
(2) Molars broad and premolar series relatively long....... *Achaenodon*

3. Hypoconulid of M_1 and M_2 developed on crest between hypoconid and entoconid. Talonid broadly basined. P_4 without metaconid DIACODEXINAE
a. Cusps sharply defined, paraconid and hypoconulid distinct. Hypocone of upper molars weak or absent......................... *Diacodexis*
b. Cusps inflated (both M^1 and M^2 believed to have hypocone).
(1) Paraconid and hypoconulid distinct..................... *Wasatchia*
(2) Paraconid weak or absent and hypoconulid less distinct.. *Bunophorus*

B. Cheek teeth moderately to highly selenodont.

1. P_1 and lower canine approximately equal OROMERYCIDAE and probably Eocene CAMELIDAE
a. Entoconid of lower molars isolated. Protocone of upper molars bilobed posteriorly .... OROMERYCIDAE
(1) Enamel rugose. Upper molar teeth oblique, transversely compressed posteriorly, and increasing in size from M^1 to M^3. External styles prominent............................. *Oromeryx*
(2) Enamel rugose to smooth. Upper molar teeth more nearly rectangular and increasing in size from M^1 to M^3. No significant diastemata between premolars. External styles prominent *Protylopus*
(3) Enamel rugose. Upper molar teeth nearly rectangular, not oblique, and more nearly equal in size from M^1 to M^3. External styles reduced and ribs much emphasized (lower teeth not known) *Malaquiferus*
(4) Enamel comparatively smooth. Marked diastemata between P_2 and P_3 (upper teeth not known)....................... *Camelodon*
b. Posterior crest of protoconid joined to metaconid and anterior crest of hypoconid joined to entoconid so that the trigonid and talonid columns of the lower molars are separate enamel loops, joined only by the lingual wall. Protocone of upper molars completely crescentic, not bilobed posteriorly.......................... POËBROTHERIINAE
(1) Lower molars with weak metastylid flexure on lingual wall and this surface is somewhat convex lingually over metaconid and entoconid. M_3 with hypoconulid loop. Upper molars with compressed, outstanding parastyles and mesostyles........ *Poëbrodon*

2. P_1 caniniform. Lower canine similar to incisors.
a. Upper molars with prominent parastyle and ribs, but no mesostyle. P^2 and P^3 without accessory cusps. P_4 with metaconid and simple talonid basin .... HYPERTRAGULINAE
(1) Posterior crest of protocone of upper molars directed toward metaconule. Anterior crest of hypoconid of lower molars directed toward posterior crest of protoconid so as to leave a small median pocket or basin between the crest of the hypoconid and the lingual wall of the tooth........................ *Simimeryx*
b. Upper molars with prominent parastyle and mesostyle, and ribs prominent (early) to weak (later). Posterior crest of protocone

directed toward metaconule. Protoconule present but may be weak. In lower molars anterior crest of hypoconid directed toward posterior crest of protoconid, and lingual cusps of these teeth with prominent styles..................Eocene AGRIOCHOERIDAE

(1) Snout not elongate. Canine above and P_1 not greatly enlarged. Primary cusp of P^4 may be twinned. Early forms somewhat bunodont but increasingly crescentic in time.........*Protoreodon*

(2) Snout elongate and very broad between the much enlarged canines. Primary cusp of P^4 with lingual ridges but not twinned. Upper molars transversely broad and not high crested.....*Diplobunops*

c. Upper molars with prominent ribs and styles externally and highly crescentic lingual cusps. Posterior crest of protocone directed laterally toward valley between paracone and metacone. Lingual styles of lower molars subdued, but outer cusps highly crescentic, with anterior crest of hypoconid directed lingually toward saddle between metaconid and entoconid.........................LEPTOTRAGULINAE

(1) P^2 and P^3 with prominent tritocone. P_3 and P_4 with posterolingually directed crest from apex or near apex of protoconid and well-developed parastylid ....*Leptotragulus*

(2) P^2 and P^3 with weak or no tritocone. P_3 and P_4 with prominent metastylid and usually prominent entoconid, but parastylid not separately defined ....*Leptoreodon*

(3) Lower premolars and molars distinctly hypsodont. Metaconid of P_4 weak though distinct (upper teeth not known)...*Poabromylus*

P_1 is caniniform: AGRIOCHOERIDAE, HYPERTRAGULIDAE, and LEPTOMERYCIDAE.

P_1 and lower C approximately equal: HOMACODONTINAE (as far as known), OROMERYCIDAE (except *Eotylopus*), and POËBROTHERIINAE.

Lower C is caniniform: HELOHYINAE (not verified for *Helohyus*).

Upper molars with posterior crest of protocone directed toward hypocone: AGRIOCHOERIDAE and *Simimeryx*.

Upper molars with posterior crest of protocone bilobed or bifurcate: OROMERYCIDAE.

Upper molars with posterior crest of protocone directed toward valley between paracone and metacone: POËBROTHERIINAE and LEPTOMERYCIDAE.

Protocone of upper molars essentially conical: HOMACODONTINAE, HELOHYINAE, and DIACODEXINAE.

Upper molars with mesostyle distinct: *Bunomeryx, Pentacemylus, Mytonomeryx*, LEPTOMERYCIDAE, AGRIOCHOERIDAE, OROMERYCIDAE, and CAMELIDAE.

Upper molars with mesostyle very weak: *Hylomeryx* and *Antiacodon.*

Upper molars without mesostyle: *Homacodon, Mesomeryx, Microsus*, DIACODEXINAE, HELOHYINAE, and HYPERTRAGULIDAE.

Upper molars with hypocone on M^1 and M^2: *Homacodon, Microsus, Antiacodon, Hylomeryx, Mytonomeryx*, and *Bunophorus?*.

Upper molars with hypocone on M^1 only (vestige or absent on M^2): *Bunomeryx.*

Upper molars without hypocone (vestige or absent on M^1): *Mesomeryx, Pentacemylus*, HELOHYINAE (very small cingular cusp in *Helohyus*), *Diacodexis,*

CAMELIDAE, AGRIOCHOERIDAE, OROMERYCIDAE, HYPERTRAGULIDAE, and LEPTOMERYCIDAE.

Upper molars with distinct protoconule: *Homacodon, Microsus, Antiacodon, Bunomeryx, Pentacemylus, Mytonomeryx, Helohyus, Diacodexis, Wasatchia?, Bunophorus?, Protoreodon* (except one species), and *Diplobunops.*

Upper molars with weak protoconule, nearly lost in loph with protocone: *Mesomeryx?, Hylomeryx, Simimeryx,* and *Protoreodon* (one species).

Upper molars without protoconule: *Achaenodon?,* CAMELIDAE, OROMERYCIDAE, and LEPTOMERYCIDAE.

P_4 with metaconid distinct: *Bunomeryx, Hylomeryx* (late), *Pentacemylus, Mytonomeryx, Microsus, Hexacodus* (in part), *Antiacodon, Protoreodon, Diplobunops,* and *Leptoreodon.*

P_4 with metaconid weak: *Hexacodus* (part), *Hylomeryx* (early), and *Poabromylus.*

P_4 with posterointernal crest instead of metaconid: *Protylopus* and *Leptotragulus.*

P_4 without metaconid: *Homacodon,* HELOHYINAE, DIACODEXINAE, and *Simimeryx.*

Lower molars with emphasized styles lingually on metaconid and entoconid: AGRIOCHOERIDAE.

Lower molars with moderate styles on metaconid but subdued or absent from entoconid: OROMERYCIDAE, *Simimeryx,* and LEPTOTRAGULINAE.

Lower molars without or with but feebly developed lingual styles: HOMACODONTINAE, HELOHYINAE, DIACODEXINAE, and POËBROTHERIINAE.

Lower molars with parastylid on anterior crest of metaconid: *Protylopus* (early stages), *Oromeryx?, Camelodon?,* AGRIOCHOERIDAE, and LEPTOTRAGULINAE.

Lower molars with parastylid from anterior crest of protoconid: *Protylopus* (later stages).

Lower molars with paraconid placed close to metaconid, possibly developed by twinning: *Microsus* (M_1 and possibly other molars), *Hexacodus, Antiacodon, Diacodexis, Wasatchia, Helohyus, Lophiohyus,* and *Parahyus* (M_1).

Lower molars without paraconid or parastylid: *Homacodon* (possibly on M_3?), *Bunomeryx, Hylomeryx, Pentacemylus, Mytonomeryx,* and *Poëbrodon.*

Lower molars with crescentic outer cusps, but distinct median pocket developed by forward direction of anterior crest of hypoconid. Entoconid united forward with crest only to metaconid: AGRIOCHOERIDAE and *Simimeryx.*

Lower molars with crescentic outer cusps, but distinct median pocket opens lingually posterior to the metastylid. Entoconid isolated forward: OROMERYCIDAE.

Lower molars with crescentic outer cusps, but anterior crest of hypoconid as well as posterior crest of protoconid directed lingually. Entoconid united foward by crest only with metaconid: LEPTOTRAGULINAE.

Lower molars with crescentic outer cusps, but anterior crest of hypoconid as well as posterior crest of protoconid directed lingually and united separately with entoconid and metaconid, respectively. Entoconid united forward by crest to metaconid as well as to hypoconid: POËBROTHERIINAE.

Lower molars essentially bunodont with no significant crest between metaconid and entoconid: HOMACODONTINAE, HELOHYINAE, and DIACODEXINAE.

M_1 and M_2 with pronounced hypoconulid developed from cingulum and posterior to saddle between hypoconid and entoconid: HOMACODONTINAE.

M_1 and M_2 with pronounced hypoconulid developed on crest or saddle between hypoconid and entoconid: DIACODEXINAE (generally weak in *Bunophorus*).

M_1 and M_2 with weak hypoconulid often on both cingulum posteriorly and in saddle between hypoconid and entoconid, very close to hypoconid: *Helohyus.*

M_1 and M_2 of forms having crescentic lower molars with hypoconulid often though not invariably developed as a posteriorly directed spur from posterior crest of hypoconid: AGRIOCHOERIDAE and OROMERYCIDAE.

M_1 and M_2 of forms having crescentic lower molars with hypoconulid often though not invariably developed as an enlarged or emphasized postero-internal extremity of the crest of the hypoconid: LEPTOTRAGULINAE.

M_1 and M_2 essentially without hypoconulid: *Parahyus, Achaenodon,* and POËBROTHERIINAE; sometimes AGRIOCHOERIDAE and LEPTOTRAGULINAE.

SYSTEMATIC REVISION

Family DICHOBUNIDAE Gill, 1872

As arranged by Simpson (1945) this family includes the two subfamilies Dichobuninae and Homacodontinae. Within the Dichobuninae he has included, along with the various European genera, the three North American lower Eocene forms, *Diacodexis, Wasatchia,* and *Bunophorus.* Structurally these three are similar to one another and are properly grouped together, but basically they are less like the dichobunes, as represented by such genera as *Dichobune, Meniscodon* and *Mouillacitherium,* than are the homacodonts. I am convinced that their degree of relationship is best indicated by separating them into a separate subfamily within the Dichobunidae and designated, as shown in the accompanying chart, by the name of Diacodexinae.

Among the middle Eocene forms, Simpson, as tentatively suggested by Matthew and Granger (1925), has included *Helohyus* in the Choeropotamidae. I am rather inclined to believe, as Stehlin (1906) has indicated and as followed by Sinclair (1914), that *Helohyus* has affinities with the Dichobunidae. The degree of relationship, however, I again regard as best represented by a subfamily separation, including the end product *Achaenodon,* an arrangement anticipated by Matthew and Granger (1925) as an alternate possibility. Nevertheless, their indication that under such an arrangement the forms included would comprise the family Helohyidae is followed only to a degree, because, referring to Matthew's (1910, p. 41) earlier thinking in connection with *Eotylopus:* "If we adopt the 'linear' system and ignore the more important and obvious structural differences between animals, on the plea that they are merely stages in specialization, if we scatter apart a closely related group of ancestral forms among widely divergent types to which they have given rise,

we involve ourselves in a very doubtful and changeable arrangement, dependent upon hypotheses of relationship instead of facts of structural affinity." As explained later, the name Helohyinae is used rather than Zittel's name Achaenodontinae.

Subfamily Homacodontinae Peterson, 1919

Two of the dichobunids listed by Simpson (1945) as uncertain in position, *Microsus* and *Antiacodon,* would both appear to be homacodonts. *Microsus,* the oldest of the North American dichobunid names, is clearly to be placed among the homacodonts. Comparison of the type of *Microsus cuspidatus* Leidy with the lower jaw belonging to the type of *Homacodon vagans* Marsh reveals little to distinguish these forms but size. The *Microsus cuspidatus* type has teeth approximately 20 percent smaller and, in addition, the cusps appear to be relatively high and more acute, with the hypoconid and entoconid better separated. However, the teeth in the *M. cuspidatus* type are less worn than in *H. vagans,* and referred material of *M. cuspidatus* has the hypoconid and entoconid less well separated. Moreover, *Microsus* shows greater tendency to retain the paraconid. It is usually distinct on M^1, variable on M_2, and usually absent from M_3. *Homacodon* is in all probability a genus distinct from *Microsus* but there is rather little to show this in posterior lower molars. In referred material of *M. cuspidatus* it should be noted that P_4 exhibits a metaconid not seen in *H. vagans,* suggesting that the later homacodonts may be more closely allied to *Microsus* than to *Homacodon.* Certain undescribed upper molars in the Bridger collections of the American Museum (Nos. 12146 and 12696), cataloged as questionably *Homacodon,* are almost certainly of *Microsus.* They agree structurally in almost all details with *Homacodon vagans* but are distinctly smaller and the cusps are more delicate and acute, as they would be in *Microsus.*

The genus *Antiacodon* was based on the species *A. venustus* Marsh, but careful comparison of type materials shows this species to be a synonym of *Sarcolemur pygmaeus* (Cope) (=*S. furcatus* Cope), likewise a genotype. Nevertheless, the generic name *Antiacodon* has priority so that the type species becomes *Antiacodon pygmaeus.* Recently (Gazin, 1952, p. 73) the record of the *Antiacodon* stem has been extended down into the lower Eocene by the discovery there of *Hexacodus.* The trigonid of the lower molars in *Hexacodus* shows *Antiacodon* peculiarities in an incipient stage but with less difference from the structure of this part seen in *Microsus.* The talonid of the lower molars, with particular attention to the hypoconulid, is very

much as in *Microsus* and *Homacodon,* and rather like *Protodichobune* as well. *Hexacodus,* and hence *Antiacodon,* are regarded as homacodonts but in a sequence somewhat divergent. Although the end product, *Antiacodon,* would appear to be significantly different and markedly divergent from *Microsus* and *Homacodon,* I have not felt that full subfamily recognition was justified, particularly since *Hexacodus* so closely resembles *Microsus.*

The remaining known genera of homacodonts, i.e., *Bunomeryx, Hylomeryx, Sphenomeryx, Mesomeryx,* and *Pentacemylus,* are all peculiar to the upper Eocene and herein discussed at greater length. One of these, *Sphenomeryx,* is regarded as a synonym of *Hylomeryx,* and the new genus, *Mytonomeryx,* is described. Remains representing species of these have been found so far only in the Uinta formation, except for *Pentacemylus progressus* Peterson, which was originally named from a Duchesne River specimen. *Pentacemylus* is now much better represented by Uinta C material.

Genus BUNOMERYX Wortman, 1898

Type.—*Bunomeryx montanus* Wortman, 1898.

Discussion.—The genus *Bunomeryx* was described by Wortman as a part of his study of the Camelidae, and he recognized its relationship to earlier *Homacodon* while suggesting tentatively that the camels may likewise have so originated. *Bunomeryx* is clearly related to *Homacodon* but is advanced over the Bridger genus in several respects. The outer cusps of the upper molar teeth, with the styles much more emphasized, appear somewhat crescentic in comparison. The presence of a prominent mesostyle is in marked contrast to the older form. The talon of the upper molars shows a progressive development of the protoconule, more noticeable in M^2 and M^3, and a reduction of the hypocone in M^2. P^4 shows a somewhat more crescentic outer wall and the deuterocone in P^3 is more pronounced.

The outer cusps of the lower molars are perhaps a little more crescentic than in *Homacodon,* and the hypoconid joins the trigonid more conspicuously. The premolars are lower crowned, but the most striking difference lies in the well-developed metaconid of P_4 in *Bunomeryx,* possibly indicating a closer relationship to *Microsus.*

BUNOMERYX MONTANUS [5] Wortman, 1895

Type.—Rostral portion of a skull with P^2-M^3 on left side and right canine, and left ramus of mandible with P_4-M_3, A.M. No. 2071.

[5] Illustrated in Peterson, 1919, pl. 36, figs. 3-4.

Horizon and locality.—Uinta C, White River, Uinta Basin, Utah.

Discussion.—*Bunomeryx montanus* is the type species and is characterized by having its lower premolar teeth in a continuous sequence, without a diastema between P_2 and P_3.

There is no indication in Wortman's paper as to the locality within the Uinta Basin from which the type was obtained, but specimen labels bear the information "White River" and "Level C." Three referred specimens in the collections of the U. S. National Museum were found in the White River pocket to the south of the White River near its junction with the Green River. This would indicate a level in the upper part of Uinta B, showing that the vertical range is not restricted to "C." Moreover, it seems probable that if the type is actually from Uinta C the level represented is low.

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Bunomeryx montanus*, A.M. NO. 2071

Length of upper cheek tooth series, anterior margin of canine alveolus to posterior margin of M^3	36.6*a*
Length of upper cheek tooth series, anterior margin of alveolus for P^1 to posterior margin of M^3	32.1
Premolar series, anterior margin of alveolus for P^1 to posterior margin of P^4	17.8
Molar series, M^1-M^3, inclusive	14.7
P^3, anteroposterior diameter : transverse diameter*	4.9 : 3.9
P^4, anteroposterior diameter : transverse diameter	4.0 : 5.1
M^1, anteroposterior diameter : transverse diameter*	5.2 : 6.1
M^2, anteroposterior diameter : transverse diameter	5.1 : 6.9
M^3, anteroposterior diameter : transverse diameter	5.1 : 7.0
Lower cheek teeth, P_4-M_3, inclusive	21.9
Lower molar series, M_1-M_3, inclusive	16.9
P_4, anteroposterior length : greatest transverse width	5.2 : 3.0
M_1, anteroposterior diameter : transverse diameter of talonid	4.8 : 3.3
M_2, anteroposterior diameter : transverse diameter of talonid	5.4 : 4.1
M_3, anteroposterior diameter : transverse diameter of trigonid	6.8 : 3.9

a, Approximate.

* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

BUNOMERYX ELEGANS [6] Wortman, 1898

Type.—Palatal portion of skull with P^2-M^3 of right and part of left series, and both rami of mandible, right with P_2-M_3, A.M. No. 2066A.

Horizon and locality.—Uinta, White River, Uinta Basin, Utah.

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[6] Illustrated in Wortman, 1895, fig. 2.

Discussion.—Bunomeryx elegans was the second of the two species described by Wortman. The principal justification given for separate recognition is in the short diastema between P_2 and P_3. Also, Wortman stated that all the teeth in *B. elegans* are smaller, and particularly P_4, which is considerably narrower and has a less-developed internal cusp. Moreover, it is stated that M^2 has a better-developed hypocone. Doubt may be entertained as to the validity of this species, as some of the characters cited cannot be well defended. The length of the diastema between P_2 and P_3 in *B. elegans* is about 2.5 mm. In a Carnegie Museum specimen (No. 2951), that was referred to by Peterson (1919, p. 67) and otherwise corresponds to *B. elegans,* there is a diastema of 1.3 mm. On the other hand, a U.S.N.M. specimen (No. 20394) of *B. montanus,* that has this portion preserved, has a diastema of 1.1 mm., so that Wortman's "most important" difference appears to be a variable character. Moreover, not all the teeth of *B. elegans* are smaller, as M^2 and probably M^3 are equally as large as in the type of *B. montanus.* The lower teeth, however, are narrower and P_4 is shorter, and although these differences are not great it is on

MEASUREMENTS IN MILLEMETERS OF DENTITION IN TYPE SPECIMEN OF *Bunomeryx elegans,* A.M. NO. 2066

Length of upper cheek tooth series, P^2-M^3, inclusive	28.7*a*
Length of upper molar series, M^1-M^3, inclusive	15.5*a*
P^2, anteroposterior diameter : transverse diameter*	4.3 : 1.7
P^3, anteroposterior diameter : transverse diameter	4.6 : 3.6
P^4, anteroposterior diameter : transverse diameter	3.7 : 4.7
M^1, anteroposterior diameter : transverse diameter*	5.0 : 5.8
M^2, anteroposterior diameter : transverse diameter	5.4 : 6.8
M^3, anteroposterior diameter : transverse diameter	5.4 : ...
Length of lower cheek tooth series, anterior margin of canine alveolus to posterior margin of M_3	38.4*a*
Length of cheek tooth series, anterior margin of alveolus for P_1 to posterior margin of M_3	35.5*a*
Length of premolar series, anterior margin of alveolus for P_1 to posterior margin of P_4	18.8*a*
Length of molar series, M_1-M_3, inclusive	16.7
P_2, anteroposterior diameter : greatest transverse diameter	4.6*a* : 1.7
P_3, anteroposterior diameter : greatest transverse diameter	4.7 : 2.1
P_4, anteroposterior diameter : greatest transverse diameter	4.7 : 2.8
M_1, anteroposterior diameter : transverse diameter of talonid	5.2 : 3.6
M_2, anteroposterior diameter : transverse diameter of talonid	5.2 : 3.9
M_3, anteroposterior diameter : transverse diameter of trigonid	6.9 : 3.5

a, Approximate.

* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

the basis of them that a tentative separation may be made. The greater development of the vestigial hypocone on M^2 and the lesser development of the metaconid on P_4 are not significant.

There is no certain indication on the specimen label of the type of *B. elegans* as to the horizon of the Uinta in which it was found, except that it came from near the White River. Carnegie Museum No. 2951, referred to *B. elegans,* has the information "Uinta B, Wagonhound, White River, near Ouray, Utah," on the label accompanying it, so that so far only Uinta B has been demonstrated for this species.

Genus **HYLOMERYX** Peterson, 1919

Synonym?.—Sphenomeryx Peterson, 1919.

Type.—Hylomeryx annectens Peterson, 1919.

Discussion.—The genus *Hylomeryx,* the second dichobunid to be named from the Uinta, appears to be clearly distinct from *Bunomeryx* and, although contemporary with the latter, it is more like *Homacodon* in many respects. The outer cusps of the upper molars are, for the most part, rather more conically bunodont than in *Bunomeryx,* resembling *Homacodon.* Also, as in *Homacodon,* the hypocone is a well-developed, circular cone on M^1 and M^2 and but a very slight expression of the cingulum on M^3. The mesostyle is very weak or in an incipient stage, intermediate between *Homacodon* and *Bunomeryx.* The protoconule, however, is rather different from both in that it seems scarcely defined on the protoloph of M^2 and M^3. It is more distinctive on M^1.

The premolar teeth, both upper and lower, are relatively large and robust in comparison with those in species of *Bunomeryx.* Moreover, small diastemata may separate P^1 and P_2 from the adjacent premolars. In the lower premolar series, P_4 has a parastylid and metaconid, but the latter may be weak or blunt in the Uinta B stage to somewhat inflated in the Uinta C stage.

The lower molar teeth are not readily distinguished from those of *Bunomeryx,* although in the type of *Hylomeryx annectens* the protoconid and hypoconid would appear to be a little less crescentic.

Sphenomeryx was defined by Peterson as distinct from *Hylomeryx* principally on the absence of a hypocone (posterointernal cusp) on M^1 and the weakness of the deuterocone on P^3. As far as M^1 is concerned, this appears to have been a misinterpretation. M^1 is rather well worn but under the microscope it is clear, from the enamel construction midway on the metaloph, lingual to the metaconule, that the

hypocone was a well-developed cusp and not just a cingular shelf or prominence. The character of the deuterocone on P^3 is scarcely more than specific in importance when taken with the many similarities. Resemblances allying *Sphenomeryx* to *Hylomeryx* are the very weak or incipient mesostyles; conical paracone, metacone, and (evidently) hypocone; and weak protoconule which nearly loses its identity in a protoloph. As a consequence, *Sphenomeryx* is regarded as a synonym of *Hylomeryx;* however, the single species *"S." quadricuspis* is reported from a later stage of the Uintan and on the basis of small differences noted is retained as a species distinct from *H. annectens.*

HYLOMERYX ANNECTENS [7] Peterson, 1919

Type.—Anterior portion of a skull and lower jaws, C.M. No. 2335.

Horizon and locality.—Uinta B, Red Bluff wash between White and Green Rivers, Uinta County, Utah.

Discussion.—*Hylomeryx annectens* is a little larger, particularly in the premolars, than *Bunomeryx montanus.* P^3 in the type specimen shows a prominent deuterocone much as in *B. montanus,* but P^4 as exposed on the right side appears abnormal. The outer wall is

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Hylomeryx annectens,* C.M. NO. 2335

Length of upper cheek series, anterior margin of alveolus for P^1 to posterior margin of M^3	38.5
Upper premolar series, anterior margin of alveolus for P^1 to posterior margin of P^4	22.1
Upper molar series, M^1-M^3, inclusive	16.5
P^2, anteroposterior diameter : greatest transverse diameter	5.4 : 2.1
P^3, anteroposterior diameter : transverse diameter*	5.8 : 4.5
P^4, anteroposterior diameter : transverse diameter	4.8 : 5.1
M^1, anteroposterior diameter : transverse diameter*	5.7 : 6.5
M^2, anteroposterior diameter : transverse diameter	5.7 : 6.9*a*
M^3, anteroposterior diameter : transverse diameter	5.4 : 6.7
Lower cheek tooth series, anterior margin of alveolus for P_2 to posterior margin of root portion of M_3	37.8*a*
Lower molar series, M_1 to posterior margin of root portion of M_3	18.5*a*
P_4, anteroposterior diameter : greatest transverse diameter	5.9 : 3.3
M_1, anteroposterior diameter : transverse diameter of talonid	5.8 : 3.7
M_2, anteroposterior diameter : transverse diameter of talonid	5.8*a* : 4.1
M_3, anteroposterior diameter : transverse diameter of trigonid	7.0*a* : 4.0

a, Approximate.

* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

[7] Illustrated in Peterson, 1919, figs. 8-10, pl. 36, figs. 5-6.

strikingly convex, anteroposteriorly, and the primary cusp and deuterocone seem pinched together, not at all like other Uintan dichobunids. The occlusal surface of this tooth on the left side is not exposed, but the external wall appears comparatively normal; as a consequence, characters exhibited by the right P^4 probably should not be stressed. If P_4, the corresponding tooth below and on the same side, can be regarded as normal, the metaconid is very weak. It represents a stage of development advanced over *Homacodon vagans,* but apparently less progressive in this respect than in *Microsus cuspidatus,* as observed in referred specimens of these Bridger forms.

HYLOMERYX QUADRICUSPIS [8] (Peterson), 1919

Plate 3, figure 4

Type.—Portions of right and left maxillae and rami of the mandible, C.M. No. 2346.

Horizon and locality.—Uinta C, south of Kennedy's hole, west of Dragon-Vernal road, Uinta County, Utah.

Discussion.—*Hylomeryx quadricuspis* is the type of the genus *Sphenomeryx* which is regarded as a synonym of *Hylomeryx.* The species *H. quadricuspis* is apparently distinct but very close in size to *H. annectens.* The anteroposterior dimensions of the upper and lower teeth are about the same in the types of the two species; however, the upper molars measure a trifle less and the lowers a trifle greater in transverse width than in *H. annectens.* The principal differences noted include a weaker deuterocone on P^3 and a transversely

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Hylomeryx quadricuspis,* C.M. NO. 2346

P^3, anteroposterior diameter : transverse diameter*	5.9 : 4.1
P^4, anteroposterior diameter : transverse diameter	4.9 : 6.1*a*
M^1, anteroposterior diameter : transverse diameter*	5.4 : 6.2
Lower cheek teeth, anterior margin of alveolus for P_3 to posterior margin (estimated) of M_3	32.0*a*
Lower molar series, M_1-M_3 (estimated), inclusive	19.2*a*
P_3, anteroposterior diameter	6.1*a*
P_4, anteroposterior diameter : greatest transverse diameter	5.9 : 3.5
M_1, anteroposterior diameter : transverse diameter of talonid	5.9 : 3.9
M_2, anteroposterior diameter : transverse diameter of talonid	5.8 : 4.4
M_3, anteroposterior diameter : transverse diameter of trigonid	7.5*a* : 4.0

a, Approximate.
* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

[8] Also illustrated in Peterson, 1919, pl. 37, figs. 15-16.

much broader P^4 in *H. quadricuspis,* although as noted in the discussion of the preceding species, P_4 in *H. annectens* may not be normal. In the lower series P_4 has a better-developed and rather inflated appearing metaconid. Also, the lower molars may be just a little more crescentic.

Hylomeryx quadricuspis is recorded as coming from a higher horizon in the Uinta formation than *H. annectens* and may well be descendent from it.

Genus **MESOMERYX** Peterson, 1919

Type.—Mesomeryx grangeri Peterson.

Discussion.—Mesomeryx is a genus clearly distinct from the foregoing, having comparatively simple, bunodont teeth. It is distinguished primarily by the absence of both the mesostyle and hypocone of the upper molars. The outer walls of the upper teeth are more like *Homacodon* than are the corresponding teeth of *Hylomeryx,* as the latter exhibits an incipient mesostyle. The outer portion of the upper molars of *Mesomeryx,* and *Homacodon* as well, are surprisingly like *Hyopsodus. Mesomeryx* differs from both *Hylomeryx* and *Homacodon* in lacking the hypocone in both M^1 and M^2. It should be noted, however, that M^1 in *Mesomeryx* exhibits a definite flexure of the cingulum at the position of the hypocone, but this is in no way comparable to the development of this cusp in either *Homacodon* or *Hylomeryx.* In *Bunomeryx* the cusp, though feeble in M^2, is robust on M^1; moreover, upper molars of *Bunomeryx* further differ in the prominent development of a mesostyle. The extent to which the protoconule is defined in *Mesomeryx* molars cannot be surely determined owing to the degree of wear in the type and only known specimen of the gentotype, *M. grangeri.* This portion of the upper molars would appear to be developed as a protoloph, but in all probability the protoconule was distinct in less-advanced wear. The triangular shape of the metaconule in advanced wear would suggest that this cusp tended to be somewhat crescentic in *Mesomeryx.*

The upper premolars in *Mesomeryx* appear to be unspecialized, with P^4 rather like that in *Bunomeryx.* P^3, however, is somewhat shortened anteroposteriorly, particularly in the anterior portion, giving the deuterocone the appearance of having a more forward position on the tooth.

The lower teeth of *Mesomeryx* are not known.

Mesomeryx appears to be the only Uintan artiodactyl known which possesses a combination of characters suggesting an ancestral posi-

tion with respect to *Simimeryx* and *Hypertragulus*. This has been considered by Stock (1934) and is further discussed in the portion of this paper treating with the hypertragulids. The possible ancestry of *Mesomeryx* may likely be in a middle Eocene homacodont rather like *Homacodon,* but having a reduced or no hypocone on the upper molars. *Mesomeryx* is rather like *Microsus,* but here again the difference lies in the absence of a hypocone.

MESOMERYX GRANGERI[9] Peterson, 1919

Type.—Left maxilla with P^3 to M^2, inclusive, C.M. No. 3189.

Horizon and locality.—The horizon and locality are given as Uinta, lower C, 2 miles east of Dragon-Vernal stage road, Uinta Basin, Utah, by Peterson (1919, p. 73); however, the specimen label gives the information "Uinta B" and "N. E. of Well No. 2." It was collected by Douglass in 1908.

Discussion.—*Mesomeryx grangeri* is much the smallest of the upper Eocene artiodactyls, and almost as small as the middle Eocene *Microsus cuspidatus.* Other characters of specific importance cannot be determined as there is but one species known.

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Mesomeryx grangeri,* C.M. NO. 3189

P^3, anteroposterior diameter : transverse diameter*	4.4 : 3.3
P^4, anteroposterior diameter : transverse diameter	3.4 : 4.7
M^1, anteroposterior diameter : transverse diameter*	4.6 : 5.4
M^2, anteroposterior diameter : transverse diameter	4.8 : 6.5

* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

Genus PENTACEMYLUS Peterson, 1931

Type.—*Pentacemylus progressus* Peterson.

Discussion.—*Pentacemylus* is clearly related to *Bunomeryx* but distinctly more progressive. It is different than the earlier *Bunomeryx,* principally in exhibiting noticeably more crescentic cusps on the upper molars and in the loss of the hypocone on M^1. *Bunomeryx* has a well-developed hypocone on M^1 and a vestige on M^2, whereas *Pentacemylus* may have only a slight vestige of this cusp on the cingulum of M^1 and no evidence of it on M^2. The upper premolars appear to be only slightly more crescentic than in *Bunomeryx,* as noted principally in the deuterocones.

[9] Illustrated in Peterson, 1919, pl. 36, fig. 17.

The lower molars may be a little more hypsodont and possibly more crescentic than in *Bunomeryx*. In the lower premolar series, the paraconid of P_3 in *Pentacemylus* is more clearly defined and that in P_4 is distinctly larger.

Pentacemylus very likely evolved from *Bunomeryx,* and the differences between the two are of no great magnitude. These differences, however, appear to be definitive and rather significant considering the shortness of the interval of time separating the known materials of the species of each.

PENTACEMYLUS PROGRESSUS [10] Peterson, 1931

Plates 2 (above) and 3, figures 2, 3

Type.—Upper molars M^2 and M^3 and lower teeth, including M_1, M_2, and part of P_4, C.M. No. 11865.

Horizon and locality.—Randlett horizon of Duchesne River formation (upper Uintan), 3 miles north of Leota Ranch and 1 mile west of Green River, Uinta County, Utah.

Discussion.—The species *Pentacemylus progressus* is much larger than *Bunomeryx montanus* and only a little larger than *Hylomeryx annectens. P. progressus* and the new form herein described as *Mytonomeryx scotti* are the largest known homacodonts.

P. progressus was originally described, as noted above, from the Randlett or lower member of the Duchesne River formation, but collections obtained by the U. S. National Museum from a quarry in Myton pocket show that it is also represented in the Uinta C fauna, and by considerably more material.

MEASUREMENTS IN MILLIMETERS OF DENTITION IN SPECIMENS OF *Pentacemylus progressus*

	C.M. No. 11865 Type	U.S.N.M. No. 20440	U.S.N.M. No. 20435
Length of upper cheek tooth series, C-M^3, inclusive	....	45.6	....
Length of upper cheek tooth series, anterior margin of alveolus for P^1 to posterior margin of M^3	....	40.7*a*	....
Upper premolar series, anterior margin of alveolus for P^1 to posterior margin of P^4	....	23.0*a*	....
Upper molar series, M^1-M^3, inclusive	....	18.6	18.9
C, anteroposterior diameter : transverse diameter	....	4.0 : 2.5	....
P^3, anteroposterior diameter : transverse diameter*	....	6.4 : 5.0	6.0 : 4.4
P^4, anteroposterior diameter : transverse diameter	....	5.0 : 6.4	4.8 : 5.7

[10] Also illustrated in Peterson, 1931b, fig. 9; and Scott, 1945, pl. 1, figs. 5-6.

	C.M. No. 11865 Type	U.S.N.M. No. 20440	U.S.N.M. No. 20435
M^1, anteroposterior diameter : transverse diameter*	....	6.3 : 7.7	6.3 : 7.7
M^2, anteroposterior diameter : transverse diameter.	6.6 : 8.7*a*	6.7 : 8.6	6.7 : 8.3
M^3, anteroposterior diameter : transverse diameter.	... : 8.5	6.3 : 8.2	6.5 : 8.2

		U.S.N.M. No. 20438	U.S.N.M. No. 20437
Length of lower cheek tooth series, C-M_3, inclusive	....	48.0*a*	49.0*a*
Length of lower cheek tooth series, P_1-M_3, inclusive	....	43.4*a*	44.0*a*
Lower premolar series, P_1-P_4, inclusive	....	22.5	23.0*a*
Lower molar series, M_1-M_3, inclusive	....	20.8*a*	21.0
C, anteroposterior diameter : greatest transverse diameter	....	4.1*a* : 2.4	....
P_1, anteroposterior diameter : greatest transverse diameter	....	4.2*a* : 2.4	....
P_2, anteroposterior diameter : greatest transverse diameter	....	5.5 : 2.1	6.1 : 2.2
P_3, anteroposterior diameter : greatest transverse diameter	....	6.3 : 2.6	6.8 : 2.7
P_4, anteroposterior diameter : greatest transverse diameter	6.2 : ...	6.0 : 3.9	6.1 : 3.6
M_1, anteroposterior diameter : transverse diameter of talonid	6.2*a* : 4.4	6.3 : 4.7	6.3 : 4.9
M_2, anteroposterior diameter : transverse diameter of talonid	6.7*a* : 4.7	6.5 : 5.0	6.2 : ...
M_3, anteroposterior diameter : transverse diameter of trigonid	....	... : 4.7	8.7 : ...

a, Approximate.
* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

PENTACEMYLUS LEOTENSIS,[11] new species

Type.—Rostral portion of skull and left ramus of mandible, P.U. No. 16310.

Horizon and locality.—Upper Uinta C, Leota Ranch artiodactyl quarry, Uinta Basin, Utah.

Specific characters.—Size distinctly smaller than *Pentacemylus progressus.* Premolars relatively small and separated by short diastemata anterior to P^3 and P_4.

Discussion.—So far, all the known material of *Pentacemylus leotensis,* which consists of approximately a couple of dozen jaws and maxillae, was obtained by Princeton University from a quarry at the old Leota Ranch on the west side of the Green River several miles

[11] Named from the Leota Ranch.

above Ouray. Although there were three specimens from this quarry tentatively referred to *Pentacemylus progressus,* all those referred to *P. leotensis* are characterized by generally smaller and narrower molars. The premolar series may be about as long as in *P. progressus,* but these teeth are significantly smaller and separated from one another anteriorly by more noticeable diastemata. P_4 is decidedly small in *P. loetensis.*

An interesting comparison may be made of the artiodactyl elements in the two above-mentioned quarries. The Leota Ranch quarry, which Dr. John Clark informs me is stratigraphically higher in the

MEASUREMENTS IN MILLIMETERS OF DENTITIONS IN SPECIMENS OF *Pentacemylus leotensis*

	P.U. No. 16310 Type	P.U. No. 16351
Length of upper cheek tooth series, C (at alveolus)-M^3, inclusive	43.0*a*	43.8
Length of upper cheek tooth series, P^1-M^3, inclusive	37.0	38.5
Upper premolar series, P^1-P^4, inclusive	20.5	21.8
Upper molar series, M^1-M^3, inclusive	16.8	17.0*a*
C, anteroposterior diameter (at margin of enamel): greatest transverse diameter	......	3.0 : 2.1
P^1, anteroposterior diameter: greatest transverse diameter	4.0 : 1.8	4.1 : 1.4
P^2, anteroposterior diameter: greatest transverse diameter	4.9 : 2.3	4.5 : 1.9
P^3, anteroposterior diameter: transverse diameter*	5.4 : 4.0	5.5 : 4.2
P^4, anteroposterior diameter: transverse diameter	4.0 : 5.4	4.2 : 5.5
M^1, anteroposterior diameter: transverse diameter*	5.4 : 6.9	5.3 : ...
M^2, anteroposterior diameter: transverse diameter	5.8 : ...	6.0 : 7.7
M^3, anteroposterior diameter: transverse diameter	6.0 : 7.2*a*	......
Length of lower cheek tooth series, C (at alveolus)-M_3, inclusive	48.5	43.5
Length of lower cheek tooth series, P_1 (at alveolus)-M_3, inclusive	44.8	39.3
Lower premolar series, P_1 (at alveolus)-P_4, inclusive	24.2	21.2
Lower molar series, M_1-M_3, inclusive	20.7	18.3
C, anteroposterior diameter (at margin of enamel): greatest transverse diameter	2.2*a* : ...	2.7 : 1.6
P_1, anteroposterior diameter: greatest transverse diameter	3.0 : 1.8	......
P_2, anteroposterior diameter: greatest transverse diameter	5.0*a* : 1.7*a*	......
P_3, anteroposterior diameter: greatest transverse diameter	... : 2.3	5.4 : 2.0
P_4, anteroposterior diameter: greatest transverse diameter	5.9*a* : 3.1	5.4 : 2.9
M_1, anteroposterior diameter: transverse diameter of talonid	6.0*a* : 3.7	5.3 : 3.8*a*
M_2, anteroposterior diameter: transverse diameter of talonid	6.3 : 4.3	5.7 : 4.6
M_3, anteroposterior diameter: transverse diameter of trigonid	8.2 : 4.0	7.7 : 4.3

a, Approximate.

* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

Uinta C sequence than the *Protylopus annectens* quarry in Myton pocket, has produced, if not always smaller-, essentially narrower-toothed forms. About 90 percent of the *Pentacemylus* material from Leota quarry is *P. leotensis,* perhaps all the *Protoreodon* material is *P. primus,* and all the *Leptotragulus* specimens appear to be *L. clarki.* At Myton pocket all the pentacemylids are *P. progressus,* the equivalent large protoreodont is *P. pumilus annectens,* and about 85 percent of the *Leptotragulus* specimens are *L. medius.* It is highly improbable that the difference in each case is to be accounted for by dimorphism within a species. Moreover, the localities are less than 20 miles apart, and both *P. progressus* and *P. pumilus annectens* noted above in the Myton locality are recorded from the Randlett horizon, still later than the Leota quarry.

MYTONOMERYX,[12] new genus

Type.—Mytonomeryx scotti, new species.

Generic characters.—Elongate rostrum with marked diastemata separating the first and second premolars, above and below, from adjacent teeth. M^1 and M^2 noticeably quadrate and both with a well-developed hypocone. Upper molars moderately selenodont with prominent mesostyle.

Discussion.—Mytonomeryx resembles closely contemporary *Pentacemylus* in the progressiveness of its selenodont tooth structure over that of earlier *Bunomeryx,* but differs strikingly from *Pentacemylus* in retention of a prominent hypocone on both M^1 and M^2. In this respect it differs also from *Bunomeryx,* which has nearly or quite lost this cusp on M^2. Retention of the hypocone is suggestive of *Hylomeryx,* but in this stem there is a tendency toward the development of a protoloph and the external styles are weak, with the mesostyle weak or absent. Mytonomeryx would appear to have derived from the *Pentacemylus* line but separating from it earlier than the *Bunomeryx* stage.

MYTONOMERYX SCOTTI,[13] new species

Plates 1, 2 (below), and 3, figure 1

Type.—Skull, jaws, and other skeletal portions, U.S.N.M. No. 20401.

Horizon and locality.—Uinta C, Myton pocket, 7 miles east of Myton, Duchesne County, Utah.

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[12] From Myton, locality; and Greek μήρυξ, ruminant.

[13] Named for Prof. W. B. Scott.

Specific characters.—Comparable in size with contemporary *Pentacemylus progressus,* but with cheek teeth slightly smaller. Other characters not distinguished from those cited for the genus.

Discussion.—In addition to the particular characters of the upper molars distinguishing *Mytonomeryx,* it was noticed that the type of *M. scotti* exhibits a strikingly elongate snout with marked spacing of the premolars between the canine and P3 above and below. From the molar region forward the elongation is somewhat greater than in the larger-toothed *Pentacemylus progressus,* and relatively greater than in the smaller *Pentacemylus leotensis.* Some difficulty has been experienced in distinguishing between lower jaws of *Mytonomeryx scotti* and *Pentacemylus leotensis,* as the latter likewise shows a spacing of the premolars. Differences were noted between the two, such as broader molars, somewhat less reduced size of premolars, possibly better-developed parastylid of lower premolars, somewhat greater length of premolar series, and the absence of a diastema between P_3

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Mytonomeryx scotti,* U.S.N.M. NO. 20401

Length of upper cheek tooth series, C-M^3, inclusive	49.7*a*
Length of upper cheek tooth series, P^1-M^3, inclusive	43.1*a*
Upper premolar series, P^1-P^4, inclusive	25.8*a*
Upper molar series, M^1-M^3, inclusive	17.9
C, anteroposterior diameter (at alveolus) : greatest transverse diameter	3.8 : 2.8
P^1, anteroposterior diameter : greatest transverse diameter	4.3 : 1.8
P^3, anteroposterior diameter : transverse diameter*	6.0 : 4.6
P^4, anteroposterior diameter : transverse diameter	4.7 : 5.8
M^1, anteroposterior diameter : transverse diameter*	5.9 : 7.3
M^2, anteroposterior diameter : transverse diameter	6.3 : 7.8
M^3, anteroposterior diameter : transverse diameter	6.2 : 7.5
Length of lower cheek tooth series, C (at alveolus)-M_3, inclusive	50.1
Length of lower cheek tooth series, P_1-M_3, inclusive	46.0
Lower premolars, P_1-P_4, inclusive	26.4
Lower molars, M_1-M_3, inclusive	19.7
C, anteroposterior diameter (at alveolus) : greatest transverse diameter	2.7 : 2.1
P_1, anteroposterior diameter : greatest transverse diameter	3.6 : 2.2
P_2, anteroposterior diameter : greatest transverse diameter	5.0 : 2.1
P_3, anteroposterior diameter : greatest transverse diameter	5.7 : 2.6
P_4, anteroposterior diameter : greatest transverse diameter	5.9 : 3.6
M_1, anteroposterior diameter : transverse diameter of talonid	5.7 : 4.3
M_2, anteroposterior diameter : transverse diameter of talonid	6.0 : 4.6
M_3, anteroposterior diameter : transverse diameter of trigonid	8.5 : 4.6

a, Approximate.

* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

and P_4 in *M. scotti,* but these are not on a generic level and some, such as the size of teeth and relative size of premolars with respect to molars, are only intermediate between *Pentacemylus progressus* and *P. leotensis.* Nevertheless, the lower premolar spacing is greater and characterizes only the forward part of the series in *M. scotti,* whereas in *P. leotensis* the diastemata are short and nearly the same between all lower premolars.

Subfamily HELOHYINAE (from HELOHYIDAE Marsh, 1877)

With regard to the suprageneric arrangement suggested in the chart, *Helohyus,* though not regarded by all as an homacodont, seems closely allied to the genus *Homacodon,* so that separation of this short-lived but rapidly evolving stem with full family recognition, I believe, is unwarranted. As a subfamily its relationships are better demonstrated, and at the same time its direction and its distinctness are given recognition. I prefer also to include this subfamily along with Homacodontinae, under the Dichobunidae, because of the more clearly demonstrable relationship, as indicated in the chart, rather than with the chronologically more remote and distinctive entelodonts. The name Helohyinae is selected rather than Achaenodontinae (Zittel, 1893) as it is based on the older familial designation Helohyidae (Marsh, 1877). Moreover, this name does not carry the implication of including the entelodonts as originally defined, or of being a subfamily of the Entelodontidae as later assigned, as does Zittel's Achaenodontinae.

Genus ACHAENODON Cope, 1873

Synonym.—Protelotherium Osborn, 1895.

Type.—Achaenodon insolens Cope, 1873.

Discussion.—Achaenodon was described by Cope on the basis of the species *A. insolens,* from Washakie beds, which he regarded as an arctocyonid creodont. Osborn in 1883 demonstrated its true position to be in the Artiodactyla and, while believing it near the entelodonts, regarded it as belonging in the "ancestral Suidae." Zittel in 1893 placed the entelodonts and achaenodonts together in the subfamily Achaenodontinae under the Suidae. Matthew in 1899 proposed full family recognition, Achaenodontidae, distinct from both Suidae and Entelodontidae (Elotheriidae). He was followed in this interpretation by Peterson (1919). More recently Colbert (1938), in his study of *Brachyhyops,* considered the Achaenodontinae as a subfamily of the Entelodontidae.

Critical examination of the known *Achaenodon* material leads me to

the conclusion that *Achaenodon* and *Archaeotherium,* though both possibly somewhat similarly adapted as large bunodont, piglike animals, in many details of dental structure followed divergent lines. *Achaenodon* is almost surely derived from the Bridger *Helohyus,* and *Parahyus* is an admirable link between the two. There appear to be no important obstacles to such an interpretation, and the resemblance in the dentition is striking. *Achaenodon* achieved considerable size during the interval between Bridger D and Uinta B (or Washakie B) time and developed a somewhat shortened snout, apparently with the loss of a premolar, but the remaining premolars appear to have become robust, though closely placed or crowded. The increased size of the premolars is foreshadowed in *Helohyus* lower-jaw material from Bridger D referred to *H. lentus.* In details of the teeth the *Achaenodon* premolars retain their simple carnivorelike form, and there is little change in the lower molars except size and a somewhat more inflated appearance of the cusps. In the upper molars, however, there has been a trend toward simplification. The rather weak hypocone, which is little more than a prominence of the cingulum in *Helohyus,* is apparently lost in *Achaenodon,* and the protoconule has been much reduced or is absent so that the upper molars have become essentially four cusped.

Archaeotherium, which is first known in the Oligocene, may have evolved from *Helohyus* or quite possibly *Lophiohyus,* but this is uncertain. In contrast to *Achaenodon, Archaeotherium* developed an elongate snout and retained all its premolars in a well-spaced arrangement. It further developed various bony protuberances on the jaw and arch, and the postorbital processes of the parietal and jugal joined. In details of the teeth, P3, rather than P4, above and below, became the more prominent or highest crowned of the premolars. The upper molars, rather than becoming more simplified in their structures, gave increasing prominence to the hypocone and protoconule so that the *Archaeotherium* upper molar has essentially six nearly equal cusps and has further given rather marked prominence to the anterior and posterior cingula. Retention of cusps in the lower molars is noted in the rather distinct paraconid and prominent hypoconulid, except that in M_3 the hypoconulid is strikingly reduced (for this tooth) from the primitive structure exemplified in *Helohyus* and in even greater contrast to the development of this cusp in *Achaenodon* and *Parahyus.*

ACHAENODON INSOLENS [14] Cope, 1873

Type.—Right and left rami of the mandible with the canine, P_3, and the last two molars represented, A.M. No. 5143.

Horizon and locality.—Washakie B, "Mammoth Buttes," Washakie Basin, Wyoming.

Discussion.—*Achaenodon insolens,* the first described species, would appear to be a slender- or shallow-jawed form with relatively elongate molars. The type, according to Granger's listing (1909), is from the upper or B horizon of the Washakie beds, but lower-jaw material from the Uinta B was referred by both Osborn (1895) and Peterson (1919, fig. 11) to this species.

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Achaenodon insolens,* A.M. NO. 5143

Length of lower cheek tooth series, C (at alveolus)-M_3, inclusive...	210.0*a*
Length of lower cheek tooth series, anterior margin of alveolus for P_2 to posterior margin of M_3	180.0*a*
Lower molar series, anterior margin of alveolus for M_1 to posterior margin of M_3	92.0*a*
P_3, anteroposterior diameter : transverse diameter	24.0 : 17.5
M_2, anteroposterior diameter : transverse diameter of talonid	26.7 : 22.5
M_3, anteroposterior diameter : transverse diameter of trigonid	40.0 : ....

a, Approximate.

ACHAENODON ROBUSTUS [15] Osborn, 1883

Type.—Greater portion of the skull and the right ramus of the mandible, P.U. No. 10033.

Horizon and locality.—Washakie B, near Haystack Mountain, Washakie Basin, Wyoming.

Discussion.—Peterson (1919) regarded this species as distinct from *A. insolens* largely on the basis of the deeper jaw with somewhat shorter molars and relatively larger premolars, particularly P_4. Shallowness of the jaw in the type of *A. insolens* might have been regarded as immaturity, but the referred specimen figured by Peterson certainly exhibits well-worn teeth. The differences outlined may be no more than might possibly be accounted for in individual variation; however, it would appear that *A. robustus* is somewhat more advanced along the line of development followed in the achaenodonts and somewhat farther removed from *Parahyus* than *A. insolens.*

[14] Illustrated in Cope, 1884, pls. 57 and 57a.

[15] Illustrated in Osborn, 1883, pl. 6; and Peterson, 1919, pl. 39, figs. 1-3.

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Achaenodon robustus*, P.U. NO. 10033

Length of upper cheek tooth series, C-M^3, inclusive	185.0
Length of upper cheek tooth series, anterior margin of alveolus for P^2 to posterior margin of M^3	147.0
Upper molar series, M^1-M^3, inclusive	70.0
C, anteroposterior diameter (at alveolus) : greatest transverse diameter	31.5 : 26.5
P^3, anteroposterior diameter : greatest transverse diameter	29.0 : 16.5
P^4, anteroposterior diameter : transverse diameter	23.0 : 27.5
M^1, anteroposterior diameter : transverse diameter	21.8 : 25.8
M^2, anteroposterior diameter : transverse diameter	24.5 : 31.8
M^3, anteroposterior diameter : transverse diameter	26.7 : 30.0
Length of lower cheek tooth series, C-M_3, inclusive	210.0
Length of lower cheek tooth series, anterior margin of alveolus for P_2 to posterior margin of M_3	172.0
P_3, anteroposterior diameter : greatest transverse diameter	24.4 : 14.3
P_4, anteroposterior diameter : greatest transverse diameter	30.0 : 17.5
M_1, anteroposterior diameter : transverse diameter of talonid	22.5 : 17.5
M_2, anteroposterior diameter : transverse diameter of talonid	24.2 : 19.5
M_3, anteroposterior diameter : transverse diameter of trigonid	36.8 : 23.0

ACHAENODON UINTENSIS [16] Osborn, 1895

Type.—Skull with shattered teeth, A.M. No. 1822.

Horizon and locality.—Uinta B, eastern portion of Uinta Basin, Utah.

Discussion.—*Achaenodon uintensis* was originally described by Osborn as *Elotherium uintense* and provisionally given the new generic name *Protelotherium*. Peterson, in his monograph on the entelodonts, placed this genus in synonomy with *Achaenodon* and in 1919 outlined his reasons. There appears to be little doubt but that *Protelotherium* is a synonym, and Peterson's critical examination of the distortions affecting the *A. robustus* skull resulted in leaving little of significance to distinguish the species *A. uintensis* other than somewhat greater size. Peterson has also noted the somewhat broader premolars in *A. uintensis* and the presence of an accessory cuspule on M^3. Much of Peterson's study of this form was based on two referred skulls in the Carnegie Museum stated to be from the same horizon and locality as the type. In reexamining these specimens, as well as material in the American Museum referred to this species, I find differences in proportions between them, particularly in the measurements of teeth, fully as great as there is between the smaller of these and the *A. robustus* type. I am much inclined to regard the species *A.*

[16] Illustrated in Osborn, 1895, figs. 16-17; and Peterson, 1919, pl. 47, figs. 1-4.

uintensis as not distinct from *A. robustus,* but since the two are not from the same beds and there may be some doubt as to their age equivalence, *A. uintensis* is tentatively retained.

MEASUREMENTS IN MILLIMETERS OF DENTITION IN A REFERRED SPECIMEN [17] OF *Achaenodon uintensis,* A.M. NO. 2047

Length of upper cheek tooth series, anterior margin of alveolus for C to posterior margin of M^3	210.0*a*
Length of upper cheek tooth series, anterior margin of alveolus for P^2 to posterior margin of M^3	175.0*a*
Upper molar series, M^1-M^3, inclusive	83.5
C, anteroposterior diameter (at alveolus) : greatest transverse diameter	35.5 : 35.5
P^3, anteroposterior diameter : greatest transverse diameter	32.0 : 23.5
P^4, anteroposterior diameter : greatest transverse diameter	27.5 : 35.5
M^1, anteroposterior diameter : transverse diameter anteriorly	25.0 : 31.0
M^2, anteroposterior diameter : transverse diameter anteriorly	27.0 : 37.0
M^3, anteroposterior diameter : transverse diameter anteriorly	32.5 : 36.0

a, Approximate.

Genus PARAHYUS Marsh, 1876

Type.—*Parahyus vagus* Marsh, 1876.

Discussion.—The close resemblance of *Parahyus* to *Achaenodon* was observed by Osborn (1895), who did not regard the genera as distinct. Osborn noted, however, that Cope believed them to be different, primarily on the assumption that *Achaenodon* had one more premolar. Although this distinction does not exist, *Parahyus* has been rather generally treated as a separate genus, possibly in part as a result of the doubt regarding its geologic age. *Parahyus,* like *Achaenodon,* is characterized by three large, single-cusped premolars, with P_4 much the largest, and simple bunodont molars. However, the one valid species, in addition to being much smaller than *Achaenodon,* has molars relatively much longer in relation to the depth of the jaw and to the length of the premolar series than in *Achaenodon,* in which respect it is about intermediate between *Helohyus* and *Achaenodon.* Like *Achaenodon* it differs from *Helohyus* essentially in the loss of a premolar (if the latter had four, as suggested by Sinclair in 1914); in the more-inflated appearance of the cusps; and in the reduction or suppression of the paraconid on the lower molars and of the hypoconulid on M_1 and M_2.

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[17] Teeth not preserved in type specimen.

PARAHYUS VAGUS[18] **Marsh, 1876**

Type.—Right ramus of mandible with P_3-M_3, Y.P.M. No. 10972.

Horizon and locality.—The type was described by Marsh as coming from the lower Eocene of Wyoming. This, however, I cannot believe, as *Parahyus vagus* is clearly and in every respect at a stage of development intermediate between Bridger *Helohyus lentus* and Washakie B or Uinta B *Achaenodon insolens.* Moreover, during an intensive field program involving the lower Eocene of southwestern Wyoming in the past several years, no further evidence has been discovered of such a form in the Wasatchian. With the help of Dr. J. T. Gregory, I have carefully gone over the data which accompanied the material in the Marsh collection and have extracted the following information from the labels: The tray label for the type of *P. vagus* bears the information "Lower Eocene Washakie?, Coryphodon zone, Wyoming Bitter Creek Station"; the old exhibition label—"Eocene (Bridger), Bitter Creek Station, J. Heisey Coll. 1876"; and the shipping label—"Bitter Creek Station, Formation ash color, 200 feet above coal, July 8, 1876, J. Heisey." The information gained here is completely confusing, but the principal evidence is that the specimen was included in a shipment made from Bitter Creek Station. Reference to Washakie in one case and Bridger in another is somewhat reassuring, but that pertaining to "Lower Eocene," "Coryphodon zone," and "200 feet above coal" is rather imperiling. It should be noted that the description of *Parahyus vagus* accompanied that of *Eohippus pernix,* and the latter undoubtedly came from the lower Eocene near Bitter Creek, as did Cope's *Coryphodon armatum.* It seems almost certain that the *P. vagus* specimen was confused with materials collected at Bitter Creek, but actually came from the Washakie beds farther to the southwest of there. Bitter Creek Station was likely the shipping point for much of that general region. It did not, of course, come from Evanston, Wyo., as implied in Matthew's 1899 tabulation.

Parahyus vagus is apparently, though not necessarily, too advanced for Bridger D, so that in all probability the occurrence was high in Washakie A or nearly transitional to Washakie B.

Discussion.—As noted above, *Parahyus vagus* is about intermediate between *Helohyus lentus* and *Achaenodon insolens* in size. This is the only known valid species, as the upper molar described by Marsh in 1894 as *Parahyus aberrans* belongs to *Helohyus.* Structurally, the *P. aberrans* tooth is entirely like upper molars of *Helohyus plicodon,*

[18] Illustrated in Peterson, 1919, fig. 12.

and in size is quite appropriate to occlude with the known lower molars of *Helohyus lentus*. In consequence of this, *P. aberrans* should be regarded as a synonym of *H. lentus.*

As for *P. vagus,* the locality data for the "*P. aberrans*" tooth are confused but would appear to be Washakie Basin, and in all probability Washakie A.

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Parahyus vagus,* Y.P.M. NO. 10972

Length of cheek tooth series, anterior margin of alveolus for P_2 to posterior margin of M_3	135.0*a*
Premolar series, anterior margin of alveolus for P_2 to posterior margin of P_4	61.0*a*
Molar series, M_1-M_3, inclusive	75.0
P_3, anteroposterior diameter : greatest transverse diameter	19.0*a* : 9.7
P_4, anteroposterior diameter : greatest transverse diameter	26.0 : 12.8
M_1, anteroposterior diameter : transverse diameter of talonid	19.3 : 13.0
M_2, anteroposterior diameter : transverse diameter of talonid	21.1 : 14.8
M_3, anteroposterior diameter : transverse diameter of trigonid	34.8 : 17.0

a, Approximate.

Family HYPERTRAGULIDAE Cope, 1879

Subfamily HYPERTRAGULINAE Matthew, 1908

Consideration of the form *Simimeryx* Stock, which appears rather certainly to be a true hypertragulid, evidently related to the Oligocene genus *Hypertragulus,* suggests possible diverse origins for the groups now united in this family. The antecedents of the Duchesnean *Simimeryx* would appear to be in a dichobunid of the type exemplified by *Mesomeryx,* whereas the leptotragulids, more highly specialized in selenodont development at an earlier date than *Simimeryx,* were likely derived from a separate portion of the dichobunid stock. This may also be true of the leptomerycines. The rather strong implication for a polyphyletic origin introduces problems in the supergeneric arrangement, so that the Hypertragulidae as currently constituted appears unnatural. I do not propose to raise all tribes or subfamilies to full family rank, as I have not been able to determine the extent to which these groups are independent. Perhaps the only forms that should be retained in the Hypertragulidae are the hypertragulids sensu stricto, *Simimeryx,* and possibly *Hypisodus* as it seems closer to *Hypertragulus* than to any of the other Oligocene forms. On the other hand, there is a suggestion that the leptotragulids and leptomerycines form a

natural family group separate from the Hypertragulidae. A tentative arrangement is as follows:

Hypertragulidae Cope, 1879
  Hypertragulinae Matthew, 1908
    Simimeryx Stock, 1934
    Hypertragulus Cope, 1873
    Nanotragulus Lull, 1922
  Hypisodontinae Cope, 1887
    Hypisodus Cope, 1873
Leptomerycidae Scott, 1899
  Leptotragulinae Zittel, 1893
    Leptotragulus Scott and Osborn, 1887
    Leptoreodon Wortman, 1898
    Poabromylus? Peterson, 1931
  Leptomerycinae Zittel, 1893
    Leptomeryx Leidy, 1853
    Heteromeryx Matthew, 1905

This does not, however, take into account the Protoceratidae. Scott (1899) was of the opinion that *Protoceras* was derived from *Leptoreodon.* However, he considered that *Stibarus* may have been a connecting link. There is much to be said in favor of an interpretation that places the leptotragulids in an ancestral position to *Protoceras,* but this does not include *Stibarus,* and the Uintan stage is much better represented by *Leptotragulus* as far as the dentition is concerned. This is most interestingly displayed by the lower premolars. There is little to distinguish the leptomerycids, leptotragulids, and protoceratids in the molar structures, but they may be diagnosed by their premolars, and among these the two that are most alike in this respect are *Protoceras* and *Leptotragulus.* The various protoceratids form a natural family group that would be obscured in the Leptotragulinae, and removing *Leptotragulus* from *Leptoreodon,* as an association of primitive and related leptomerycids, tends also to distort the picture. A suggested arrangement is shown in the phylogenetic chart.

Genus SIMIMERYX Stock, 1934

Type.—Simimeryx hudsoni Stock, 1934.

Discussion.—Stock's description of this form and estimate of its probable relationships appear quite accurate. The resemblance to *Hypertragulus* is rather close and particularly striking in characters of the premolars, both upper and lower. With these teeth the principal differences to be noted are the somewhat less reduced size anteriorly, the absence of a diastema between P_2 and P_3, the less-selenodont

deuterocone of P^4, and the less deeply basined talonid of P_4. Their general form is, nevertheless, remarkably similar.

The molar teeth of *Simimeryx* are somewhat less progressive than those of *Hypertragulus* in the achievement of selenodonty. The upper molars lack the mesostyle as do those of *Hypertragulus,* but are a little more brachydont, exhibit a slight external cingulum, and the external rib of the metacone is less outstanding. The less-selenodont character is most noticeable in the lingual portion of the upper teeth, in which the stage of development approximates that in *Protoreodon.* A small protoconule is preserved on the anteroexternal crest of the protocone, and the posterior crest of the protocone is directed toward the anterior wall of the metaconule, about as in *Protoreodon.* Also, the anterior crest of the hypoconid of the lower molars is directed toward the posterior crest of the protoconid so as to leave a small pocket or basin anteroexternal to the entoconid, somewhat as in *Protoreodon,* though perhaps less conspicuously. Selenodonty is rather advanced beyond that of the homacodonts. However, as Stock has pointed out, *Simimeryx* most nearly resembles *Mesomeryx* among the various homacodonts. Although differences were noted, some were only of degree, and there is strong indication that a homacodont rather like *Mesomeryx* gave rise to *Simimeryx.* The leptotragulids on the other hand, even as early as Uinta B time, were too highly specialized to be considered as potential ancestors or to have been derived from the same homacodont stock.

SIMIMERYX HUDSONI [19] Stock, 1934

Type.—Right maxilla with P^2 to M^3, inclusive, C.I.T. No. 1764.

Horizon and locality.—Sespe upper Eocene, C.I.T. loc. 150, Pearson Ranch, north side of Simi Valley, Ventura County, Calif.

MEASUREMENTS IN MILLIMETERS OF DENTITIONS IN SPECIMENS OF *Simimeryx hudsoni*

	C.I.T. No. 1764 Type
Length of upper cheek tooth series, P^2-M^3, inclusive	28.9
Upper premolar series, P^2-P^4, inclusive	13.4
Upper molar series, M^1-M^3, inclusive	15.8
P^2, anteroposterior diameter : greatest transverse diameter	4.4 : 1.7
P^3, anteroposterior diameter	5.3
P^4, anteroposterior diameter : transverse diameter*	4.2 : 4.4
M^1, anteroposterior diameter : transverse diameter*	5.4 : 5.9
M^2, anteroposterior diameter : transverse diameter	6.1 : 7.2
M^3, anteroposterior diameter : transverse diameter	5.5 : 7.2

[19] Illustrated in Stock, 1934, pl. 1.

	C.I.T. No. 1244
Length of lower cheek tooth series, P_1 (at alveolus)-M_3, inclusive....	42.3
Lower premolar series, P_1 (at alveolus)-P_4, inclusive...............	22.8
Lower molar series, M_1-M_3, inclusive..............................	19.7
P_1, anteroposterior diameter (at alveolus).........................	3.1*a*
P_2, anteroposterior diameter: greatest transverse diameter...........	4.2: 1.8
P_3, anteroposterior diameter: greatest transverse diameter...........	5.5: 2.6
P_4, anteroposterior diameter: greatest transverse diameter...........	5.8: 3.2
M_1, anteroposterior diameter: transverse diameter of talonid..........	5.0: 4.1
M_2, anteroposterior diameter: transverse diameter of talonid..........	5.9: 4.7
M_3, anteroposterior diameter: transverse diameter of trigonid.........	8.9: 4.9

a, Approximate.

* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

Discussion.—Included in the material upon which this species was based is also a lower jaw, C.I.T. No. 1244, with P_1-M_3, designated as a paratype, and a left maxillary portion exhibiting P^3 and P^4. In size *S. hudsoni* is rather close to *Leptotragulus clarki,* even to the length of diastema separating P_1 from P_2. The teeth, however, both upper and lower, are fundamentally different in structure.

SIMIMERYX MINUTUS [20] (Peterson), 1934

Type.—Portion of right ramus of mandible with P_4-M_2, C.M. No. 11913.

Horizon and locality.—Lapoint member of Duchesne River formation, north side of "Red Narrows," east of Tridell, Uinta County, Utah.

Discussion.—That Peterson should have referred this form, even questionably to *Leptomeryx,* is surprising, inasmuch as the P_4 is quite unlike that in the Oligocene genus. Correspondence to *Simimeryx hudsoni,* not known to Peterson at the time of his writing, is rather marked. Apparently, the only differences to be noted between the types are the much smaller size of *Simimeryx minutus* and the better-

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Simimeryx minutus,* C.M. NO. 11913

Length of lower cheek tooth series, P_4-M_2, inclusive..................	12.4
P_4, anteroposterior diameter..	3.9
M_1, anteroposterior diameter: transverse diameter of talonid..........	4.1: 2.8
M_2, anteroposterior diameter: transverse diameter of trigonid.........	4.6: 3.1*a*

a, Approximate.

[20] Illustrated in Peterson, 1934, fig. 6.

defined metaconid on P_4. The form of P_4, like that of *S. hudsoni*, corresponds more closely to that of *Hypertragulus* than it does to *Leptomeryx*. The molars of *S. minutus* are almost identical to those of *S. hudsoni*.

Family AGRIOCHOERIDAE Leidy, 1869

Genus PROTOREODON Scott and Osborn, 1887

Synonyms.—*Eomeryx* Marsh, 1894.
Hyomeryx Marsh, 1894.
Agriotherium Scott, 1898 (not Wagner, 1837).
Chorotherium Berg, 1899.
Protagriochoerus Scott, 1899.
Mesagriochoerus Peterson, 1934.

Type.—*Protoreodon parvus* Scott and Osborn, 1887.

Discussion.—Much of the taxonomic confusion earlier referred to for upper Eocene artiodactyls relates to the redundance of generic names that have been applied to these small agriochoerids. Marsh's name *Eomeryx* first appeared in 1877 in the published text of an address, but as it was given without adequate description and without designation of species it remained a nomen nudum until 1894. In the meantime, Scott and Osborn (1887) described the genus and species *Protoreodon parvus* from the Uinta. In 1894 Marsh announced that the type of his *Eomeryx* was the earlier-named species (1875) *Agriochoerus pumilus,* and at the same time named as new, *Hyomeryx breviceps*. The generic name *Agriotherium* (preoccupied) was given by Scott to his new species *"A." paradoxicus* in 1898, which Berg replaced by *Chorotherium*. In Scott's monograph on the selenodont artiodactyls of the Eocene in 1899 he reassigned this species to *Protoreodon* and at the same time named the relatively large *Protagriochoerus annectens*. More recently (1934) Peterson contributed to the growing list of synonyms by proposing *Mesagriochoerus* for the Duchesne River protoreodont.

From a review of all the types involved and much referred material, I have been led inescapably to the conclusion that *Protoreodon,* as Peterson (1919, p. 82) indicated, was essentially an agriochoerid and not a merycoidodont. It is unfortunate that the name *Protoreodon* should be the one to survive, but there appears to be no doubt of its priority.

Protoreodon differs from *Agriochoerus* principally in the less-molarized form of P^4 and P_4, retention of a protoconule on the upper molars, absence of any appreciable diastema behind the upper canine

and lower P_1, and the general, though possibly not invariable, retention of the upper incisors. Moreover, the outer walls of the upper molars of *Protoreodon* may be slightly more ribbed at the paracone and metacone. This is somewhat more noticeable in the Uinta B than in the Uinta C material. Also, the mesostyle has a more pinched or constricted appearance ventrally than is customary in *Agriochoerus*.

Resemblances to *Agriochoerus* are seen in the basic structure of both the upper and lower molars, structures that would appear to be more conservative and to show generic relationships. In the upper molars it is particularly significant that the posterior crest of the protocone in *Protoreodon* is directed at about right angles to the anterior crest of the metaconule [21] and terminates abruptly just short of a union, quite as in *Agriochoerus*. In *Merycoidodon* the posterior crest of the protocone, together with the anterior crest of the metaconule, extend parallel and deep into the valley between the paracone and metacone, somewhat as in *Leptoreodon*. In the lower molars a crest arrangement somewhat analogous to that in the upper molars persists through *Protoreodon* and *Agriochoerus*. Here the anterior crest of the hypoconid is directed toward the posterior crest of the protoconid, leaving a conspicuous pocket anteroexternal to the entoconid. In *Merycoidodon* this pocket is not developed inasmuch as the anterior crest of the hypoconid as well as the posterior crest of the protoconid are directed lingually together into the valley between the metaconid and entoconid, again rather as in *Leptoreodon*.

The lachrymal in *Protoreodon* is like that in *Agriochoerus*. It has nowhere near the forward expansion, nor the characteristic depression seen in *Merycoidodon*. The orbits are widely open posteriorly, and the posterior narial aperture extends well forward between the molars. Moreover, in the *Protoreodon* foot the distal phalanges have a somewhat compressed or more-acute dorsal surface than in *Merycoidodon*, resembling in this way, also, the agriochoerid almost clawlike structures.

I find difficulty in visualizing derivation of *Merycoidodon* from any of the better-known species of *Protoreodon*. There seems to be no certain point of origin within the *Protoreodon* complex, but I am inclined to believe that the line represented by *P. minor* and leading to the new Myton species, *Protoreodon petersoni*, is less unlikely than any part of the sequence of larger protoreodonts represented by *P. parvus* and producing the more distinctly *Agriochoerus*-like *P. pumilus annectens*.

[21] Wortman (1898) has shown that this is not the hypocone.

Leptoreodon, as noted by Wortman, comes close in the general structural plan of upper dentition, but the anterior extension of the snout as well as other skull characters would seem to preclude this genus, and I particularly note that the lower premolars, especially P_4, present greater difficulties than *Protoreodon.* The lower premolars of *Leptotragulus,* on the other hand, as exemplified by *L. medius,* would appear potentially close. In both *Leptoreodon* and *Leptotragulus* the lingual portion of the upper molars and the labial portion of the lower molars satisfactorily meet the requirements. The primary cusps, outer above and inner below, however, are decidedly more conical than in *Merycoidodon;* a condition that might be expected in a somewhat more remote ancestry of the highly crescentic pattern of *Merycoidodon.* I believe that the gap is rather significant and that the dental indications are for a closely related common ancestry rather than direct sequence. Clearly a compromise form is needed, exhibiting the paramerial form more as in *Protoreodon* and the protomerial structure of *Leptotragulus* or *Leptoreodon.*

PROTOREODON PUMILUS [22] (Marsh), 1875

Plates 4, 5, and 6, figure 2

Synonyms.—*Protagriochoerus annectens* Scott, 1899.
Protoreodon medius Peterson, 1919.
?*Protoreodon tardus* Scott, 1945.

Type.—Lower jaw fragments with M_1 and portions of M_2 and M_3 from right side and M_2 from left, including also various other skeletal fragments of Y.P.M. No. 11890.

Horizon and locality.—Vicinity of White River, Uinta Basin, Utah, probably Uinta C according to Thorpe.

Discussion.—Although Thorpe lists Y.P.M. No. 11890 as a cotype, I believe it should be regarded as the holotype, and is here so designated, inasmuch as the maxillary portions and upper molars belonging to Y.P.M. No. 11890a were referred to by Marsh (1875) as the "second specimen." It is interesting to note that neither of these specimens was figured and that the skull, Y.P.M. No. 11891, and jaws, Y.P.M. No. 10570, illustrated by Marsh in 1894, among the materials that he obtained "by subsequent researches in the Uinta basin," [23] may not represent *Protoreodon pumilus* as they appear to be closer to *Protoreodon parvus.*

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[22] Illustrated also in Scott, 1899, pl. 4, figs. 26-27; 1945, pl. 2, figs. 1, 1a; pl. 3; Peterson, 1919, fig. 13; pl. 40, figs. 1-16, 19-27, and pl. 41; and Thorpe, 1937, fig. 8; pl. 1, fig. 1.

[23] As an aside on the record of collections, Marsh (1894) claimed that the

Protoreodon pumilus is clearly the best represented species of *Protoreodon,* and its remains are by all odds the most frequently encountered in the Myton fauna. Much individual variation is noticed in size, details of the cheek teeth, and development of canines. The extremes in most details are rather well represented by the types of *P. pumilus* and *"Protagriochoerus" annectens,* and the latter might well be regarded as a variant, or mutation in time, and would have been recognized as a separate species were it not for the mass of material intervening. *Protagriochoerus* is not a valid genus, as Peterson (1919, p. 88) fully appreciated, and at the same time there appears to be no justification for Peterson's *Protoreodon medius,* which corresponds rather closely to the type of *"Protagriochoerus" annectens.* The greater selenodonty of the outer cusps of the upper molars noted by Scott as characterizing *Protagriochoerus* was evidently a comparison made with the type of *Protoreodon parvus,* which must surely be from Uinta B. The significance of this, however, on a generic level, is lost in the intervening material of *P. pumilus.* With regard to the development of the upper premolars of *P. pumilus,* the slightly more basined talon on P^3 of the referred material is rather general throughout and advanced over the condition noted in *Protoreodon parvus,* and particularly *P. paradoxicus.* P^4 shows perhaps less conspicuous difference between *P. pumilus* and *P. parvus,* but in *P. paradoxicus* the talon of P^4 is much more bunodont.

Protoreodon tardus is stated to be from the Beaver Divide conglomerate, in which case it is as late as, or later than, *Protoreodon primus,* but the transverse width of the premolars is greater than is regarded as characterizing that species, being more nearly as in *P. pumilus* in this respect, as well as in size and degree of selenodonty; hence, it is tentatively included in the latter species. It may be further noted that the division of the primary cusp and the development of the talon or deuterocone portions of P^3 and P^4 in the type of *Protoreodon tardus* are perhaps a trifle less progressive than in most referred material of *P. pumilus,* suggesting the smaller and even earlier *Protoreodon parvus.*

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material of the three small artiodactyls (*Eomeryx, Parameryx,* and *Oromeryx*) was found by himself in 1870. The labels, in Marsh's handwriting, accompanying the material originally described as *Agriochoerus pumilus* read "J. Heisey, White River, Aug. 20th, 1874" and "S. Smith, Lake Fork, Aug. 9th, 1874." All the *Oromeryx* and part of the *Parameryx* material has the field number 1057, which was for the year 1877. The remaining material of *Parameryx* is labeled "M. Forshay, Sept. 5, 1876."

Slight changes noted in the cheek teeth of *P. pumilus* are apparently to be correlated with time. It is interesting to note that most of the *Protoreodon* dentitions from the *Protylopus* quarry and vicinity in Myton pocket tend to resemble the type of *"Protagriochoerus" annectens* somewhat more closely than that of *P. pumilus*. This is noted in an average larger size and almost imperceptibly more selenodont outer cusps of lower molars as compared with materials obtained from Leland Bench draw. I am convinced that the level from which fossil material was collected along Leland Bench draw is a little earlier in Uinta C time than the quarry in Myton pocket, and that the type of *P. pumilus* which these materials closely resemble is from low in "C," which would be in keeping with the locality designation "White River" on the Marsh specimen.

In view of the average difference between specimens in the collection noted above, I am tentatively designating the more-advanced material, including much of that from Myton pocket, as the subspecies *Protoreodon pumilus annectens*.

The size of the caniniform teeth in *P. pumilus* is clearly not to be correlated with size or other characters of the cheek teeth. Large and small upper canines and lower P_1's are to be found in individuals grouped according to size and development of cheek teeth. There does appear, however, to be correlation between caniniform tooth size and the extent to which the angle is expanded posteriorly, together with the somewhat more posterior placement of the condyle, and to a minor degree the depth of the ramus generally. The latter variables are in part, of course, a function of the age of the individual as determined by wear on the cheek teeth. Specimens can be readily divided into two groups where preservation includes the upper canine or P_1, but I have been unable to make this same separation on the basis of the cheek teeth alone. I cannot regard the differences here cited as of more than dimorphic significance within the species of *P. pumilus*. It may be further noted that in those individuals which I regard as males, a slightly greater diastema developed posterior to the large C.

MEASUREMENTS IN MILLIMETERS OF DENTITIONS IN SPECIMENS OF *Protoreodon pumilus*

	A.M.[24] No. 1818	U.S.N.M. No. 20352
Length of upper cheek tooth series, C (at alveolus)-M^3, inclusive	81.5	76.0*a*
Length of upper cheek tooth series, P^1-M^3, inclusive	70.7*a*	69.3
Upper premolar series, P^1-P^4, inclusive	36.4*a*	35.0

[24] Type of *"Protagriochoerus" annectens*.

	A.M. No. 1818	U.S.N.M. No. 20352
Upper molar series, M^1-M^3, inclusive	36.0*a*	34.5a
C, anteroposterior diameter (at alveolus): greatest transverse diameter	8.5*a*: 7.1*a*	5.0: 4.7
P^1, anteroposterior diameter: greatest transverse diameter	....	7.7: 3.7
P^2, anteroposterior diameter: transverse diameter*	10.0: 5.1	9.4: 5.0
P^3, anteroposterior diameter: transverse diameter	9.5: 10.3	9.7: 8.5
P^4, anteroposterior diameter: transverse diameter	8.0: 10.5	8.2: 11.0*a*
M^1, anteroposterior diameter: transverse diameter*	....	10.7*a*: ...
M^2, anteroposterior diameter: transverse diameter	13.3: 15.8	13.0: 14.2
M^3, anteroposterior diameter: transverse diameter	13.4: 17.4	13.7: 16.0

	Y.P.M. No. 11890 Type	U.S.N.M. No. 20352
Length of lower cheek tooth series, P_1 (at alveolus)-M_3, inclusive	....	71.0*a*
Lower premolar series, P_1 (at alveolus)-P_4, inclusive	....	32.4
Lower molar series, M_1-M_3, inclusive	....	39.0
P_1, anteroposterior diameter (at alveolus): greatest transverse diameter	....	5.9: 4.1
P_2, anteroposterior diameter: greatest transverse diameter	....	8.0: 3.8
P_3, anteroposterior diameter: greatest transverse diameter	....	9.9: 4.9
P_4, anteroposterior diameter: greatest transverse diameter	....	10.0: 6.9
M_1, anteroposterior diameter: transverse diameter of talonid	9.5: 7.1	9.7: 7.5
M_2, anteroposterior diameter: transverse diameter of talonid	10.0: 7.8	11.4: 8.1
M_3, anteroposterior diameter: transverse diameter of trigonid	....	17.8: 7.8

a, Approximate.

* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

PROTOREODON PARVUS [25] Scott and Osborn, 1887

Synonym.—*Hyomeryx breviceps* Marsh, 1894.

Type.—Portions of skull and left ramus of mandible, P.U. No. 10398.

Horizon and locality.—Uinta B (according to Thorpe), Uinta County, Utah.

Discussion.—*Protoreodon parvus* is distinguished from *Protoreodon*

[25] Illustrated in Scott and Osborn, 1887, p. 257; Scott, 1889, pl. 7, figs. 1-2; Marsh, 1894, figs. 18, 19, and 22; and Thorpe, 1937, figs. 12-17; pl. 1, fig. 3.

pumilus primarily by its significantly smaller size. In addition to this there are slight differences in the structure of the teeth that may be regarded as representing a stage somewhat more primitive than is evident in the *P. pumilus* dentitions. In P^4 the primary cusp is twinned but less markedly so than in much of the *P. pumilus* material, and the talon portions of both P^3 and P^4 are slightly more constricted anteroposteriorly. It is also noted that the cheek teeth, both upper and lower, are perceptibly less selenodont. The cusps are just a little more bunodont, and the outer wall of the upper molars has slightly better-developed ribs on the paracone and metacone. *Protoreodon parvus* would appear to be ancestral in every way to *Protoreodon pumilus* and is somewhat closer to the type material of *P. pumilus* than it is to the referred material of Myton pocket, indicating a gradational sequence in which an arbitrary separation might be made corresponding about to the transition between Uinta B and Uinta C time. It should be noted, however, that a few of the larger protoreodont specimens from White River pocket (Uinta B) seem difficult to distinguish from *P. pumilus* and might also be confused with *Diplobunops vanhouteni*.

The type of *Hyomeryx breviceps* Marsh is almost indistinguishable in the upper cheek teeth from *Protoreodon parvus*. The only possibly significant character brought forth in defense of *Hyomeryx breviceps* was absence of upper incisors. I was unable to find this portion of the specimen in the collections at Yale, but there appears to be some doubt as to Marsh's interpretation, inasmuch as Thorpe noted that this portion of the premaxilla was broken down and that there may have been a small incisor. In all the *Protoreodon* material that I have examined where the alveolar portion of the premaxilla was well preserved, the three incisors were present, increasing in size from a very small I^1 to a moderate I^3. Only in certain damaged specimens was there any doubt as to the presence of all. However, inasmuch as the anterior incisors are relatively small, it would not be surprising if they were occasionally missing, possibly in some instances through damage and loss during the life of the individual. This portion is apparently not preserved in the type of *P. parvus*. Among other characters attributed to *Hyomeryx breviceps*, the absence or weakness of the internal cingulum is probably of doubtful significance, but in any case does not differ in this respect from the type of *P. parvus*. The character of the styles noted by Thorpe for the upper molars of *H. breviceps* is in part surmise, as all but the parastyle on M^1 are broken off. Marsh's illustration (1894, fig. 19) of these teeth gives the wrong impression, inasmuch as the damage is not indicated and

no restoration was made. This error was corrected in Thorpe's illustrations (1937, figs. 16 and 17).

Marsh stated that the horizon for "*H. breviceps*" was nearly the same as that for *Eomeryx* (*P. pumilus*), which may mean little more than near the White River. This would suggest lower "C" or upper "B." Although Thorpe gives the horizon as "C," I suspect that it is very low in this level, or to judge by the development of the dentition I would be inclined to regard it as more likely from Uinta B.

MEASUREMENTS IN MILLIMETERS OF DENTITIONS IN SPECIMENS OF
Protoreodon parvus

	P.U. No. 10398 Type	Y.P.M. No. 11891
Length of upper cheek tooth series, C (at alveolus)-M^3, inclusive	....	67.0
Length of upper cheek tooth series, P^1 (at alveolus)-M^3, inclusive	....	56.0
Upper premolar series, P^1 (at alveolus)-P^4, inclusive	26.8*a*	29.5
Upper molar series, M^1-M^3, inclusive	26.4	27.7
C, anteroposterior diameter (at alveolus) : greatest transverse diameter	....	8.0 : 7.0
P^3, anteroposterior diameter : transverse diameter*	7.3 : 7.4*a*	7.8 : 7.5
P^4, anteroposterior diameter : transverse diameter	6.7 : 8.8	6.5 : 8.8
M^1, anteroposterior diameter : transverse diameter*	8.0 : 10.2	8.8 : 10.0
M^2, anteroposterior diameter : transverse diameter	8.8 : 11.4	9.4 : 12.0
M^3, anteroposterior diameter : transverse diameter	10.0 : 12.8	10.0 : 13.0

	U.S.N.M. No. 20383	
Length of lower cheek tooth series, P_1 (at alveolus)-M_3, inclusive	....	60.0*a*
Lower premolar series, P_1 (at alveolus)-P_4, inclusive	....	30.0*a*
Lower molar series, M_1-M_3, inclusive	....	30.5
P_1, anteroposterior diameter (at alveolus) : greatest transverse diameter	....	8.0*a* : 5.2*a*
P_2, anteroposterior diameter	....	6.0*a*
P_3, anteroposterior diameter : greatest transverse diameter	8.9 : 4.3	....
P_4, anteroposterior diameter : greatest transverse diameter	8.6*a* : 5.7	8.0 : 4.7
M_1, anteroposterior diameter : transverse diameter of talonid	8.2 : 6.5	8.1 : 6.2
M_2, anteroposterior diameter : transverse diameter of talonid	8.8 : 7.5	8.5 : 6.8
M_3, anteroposterior diameter : transverse diameter of trigonid	... : 7.5	13.8 : 6.8

a, Approximate.

* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

PROTOREODON PARADOXICUS[26] (Scott), 1898

Type.—Skull, jaws, a few vertebrae, limb and foot bones, P.U. No. 11234.

Horizon and locality.—Upper Uinta B or lower Uinta C, mouth of White River, Utah, according to Thorpe.

Discussion.—The dentition in the type of *Protoreodon paradoxicus* is only a little smaller than that of *Protoreodon parvus.* It exhibits, however, distinctly more primitive appearing premolars. P^3, for example, is three rooted but shows scarcely more than a robust cingulum at the position of the deuterocone, and in P^4 the deuterocone is decidedly conical in comparison with that in *P. parvus.* Moreover the primary cusp in P^4 of *P. paradoxicus,* though somewhat worn, is almost certainly not twinned. The molars show noticeable wear but are perhaps more conical than in *P. parvus;* also, the parastyles are rather more outstanding. The canines in the type specimen are particularly large so that I suspect this is a male individual. I^3 is present on one side, but beyond this the premaxillae are not sufficiently complete to warrant further conclusions regarding the number of incisors.

Beyond doubt *Protoreodon paradoxicus* possesses the most primi-

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Protoreodon paradoxicus,* P.U. NO. 11234

Length of upper cheek tooth series, C (at alveolus)-M^3, inclusive	59.6
Upper premolar series, P^2-P^4, inclusive	19.5
Upper molar series, M^1-M^3, inclusive	23.4
C, anteroposterior diameter	7.0
P^2, anteroposterior diameter: transverse diameter*	6.7*a*: 3.5*a*
P^3, anteroposterior diameter: transverse diameter	6.7: 5.6
P^4, anteroposterior diameter: transverse diameter	6.4: 8.7
M^1, anteroposterior diameter: transverse diameter*	7.3: 8.8
M^2, anteroposterior diameter: transverse diameter	8.2: 8.7
M^3, anteroposterior diameter: transverse diameter	8.8: 12.1
Lower molar series, M_1-M_3, inclusive	27.1
P_3, anteroposterior diameter	7.5
P_4, anteroposterior diameter: greatest transverse diameter	8.0: 4.4
M_1, anteroposterior diameter: transverse diameter of talonid	7.1: 5.5
M_2, anteroposterior diameter: transverse diameter of talonid	8.0: 6.0*a*
M_3, anteroposterior diameter: transverse diameter of trigonid	12.5: 6.3

a, Approximate.
* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

[26] Illustrated in Scott, 1899, pl. 4, figs. 24-25; and Thorpe, 1937, fig. 11; pl. 1, fig. 2.

tive dentition of any form now included in *Protoreodon.* Separate generic recognition was considered by Scott in 1898 but abandoned the following year. I am inclined to agree that basically *P. paradoxicus* belongs to *Protoreodon,* and that the differences from other species are only those of degree, representing less-advanced development along observed trends. It should, moreover, be noted that in the illustration of the type given by both Scott (1899, pl. 4, fig. 24) and Thorpe (1937, pl. 1, fig. 2) the flattening of the skull is due to crushing and that the unusual depth of the jaw anteriorly does not take into consideration a certain amount of faulty plaster restoration.

PROTOREODON MINOR [27] Scott, 1899

Plate 6, figure 1

Type.—Right and left maxillary portions with the left side exhibiting C and P^2 to M^3, but M^1 and M^3 only partially preserved, P.U. No. 11339.

Horizon and locality.—Uinta C, Kennedy's Hole (according to Thorpe), Uinta Basin, Utah.

Discussion.—*Protoreodon minor* is only a little smaller than *Protoreodon paradoxicus* and on this character alone would not have been separable specifically from *P. paradoxicus;* however, the more-advanced condition of the upper premolars in *P. minor,* together with the fact that a distinctly later horizon is represented, causes me to regard *P. minor* as a separate species. P^3 in *P. minor* has a distinct deuterocone, and a slight basin is developed posterior to it by the extension of the posterior cingulum. In P^4 the deuterocone has better-developed crests, giving the tooth a more-selenodont appearance than in *P. paradoxicus.* On the other hand, like *P. paradoxicus,* there is no evidence for twinning of the primary cusp of P^4 in the *P. minor* type, although in a referred specimen from the Devil's Playground a slight indication of this is seen on one side only. The molars of *P. minor,* as in *P. paradoxicus,* have distinctly conical paracones and metacones, exhibiting likewise heavily ribbed outer walls. Also, the protoconule is sharply defined.

I have not seen lower teeth that belong without doubt to the *P. minor* stage, as the lower teeth associated with the type specimen are leptotraguline, probably *Leptoreodon* but not *Protoreodon.* Lower teeth of *P. paradoxicus* show distinctly conical metaconids and entoconids with a peculiarly prominent stylar development. Those of *P. minor* may have been similar.

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[27] Also illustrated in Scott, 1899, pl. 3, fig. 23; and Thorpe, 1937, fig. 10.

It is entirely possible that *P. minor* is no more than a variant in time of *P. paradoxicus* and that *P. minor* in turn gave rise to the form described as a new species, *Protoreodon petersoni,* in the Myton pocket and Leland Bench draw collections.

MEASUREMENTS IN MILLIMETERS OF DENTITIONS IN SPECIMENS OF *Protoreodon minor*

	P.U. No. 11339 Type	U.S.N.M. No. 20674
Length of upper cheek tooth series, C-M^3, inclusive, measured at alveoli	55.0	......
Length of upper cheek tooth series, P^1-M^3, inclusive, measured at alveoli	46.9	......
Upper premolar series, P^1 (at alveolus)-P^4, inclusive	25.2	......
Upper molar series, M^1-M^3, inclusive, measured at alveoli	22.0	22.0*a*
C, anteroposterior diameter (at alveolus): greatest transverse diameter	5.5 : 4.8	......
P^2, anteroposterior diameter: greatest transverse diameter	6.0 : 3.8	......
P^3, anteroposterior diameter: transverse diameter*	6.5 : 6.0*a*	6.4 : 6.5
P^4, anteroposterior diameter: transverse diameter	6.0 : 7.5	6.0 : 7.3
M^1, anteroposterior diameter: transverse diameter*	......	7.2 : 8.8
M^2, anteroposterior diameter: transverse diameter	8.1 : 11.7	8.2 : 10.4
M^3, anteroposterior diameter: transverse diameter	8.0*a* : 12.0	8.5 : 11.6

a, Approximate.
* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

PROTOREODON PRIMUS [28] (Peterson), 1934

Type.—Portion of skull and jaws, C.M. No. 11893.

Horizon and locality.—Randlett member of Duchesne River formation, Randlett Point, Uinta County, Utah.

Discussion.—The specimen that Peterson designated as the type of *Mesagriochoerus primus* from Randlett horizon and that (C.M. No. 11904) from the Halfway, which he regarded as the paratype, appear to represent a distinct species. The slenderness of the premolars noted by Peterson is distinctive. Most of the characters, however, that he cited as indicating a separate genus, and certainly those in particular that he regarded as more closely foreshadowing *Agriochoerus,* are not significant in comparison with material of *Protoreodon pumilus annectens* from Myton pocket. The twinning of the primary cusp in P^4 is no further advanced than in much of the Myton material, and the crescentic deuterocone is somewhat more like that noted in *Protoreodon petersoni* than in *Agriochoerus,* as for

[28] Illustrated in Peterson, 1934, figs. 3-5.

example, *A. minimus.* The tetartocone is actually more advanced and rather more *Agriochoerus*-like in certain specimens of *P. pumilus.* A particularly advanced tetartocone on P^4 was noted in a specimen from the Uinta C of Leland Bench draw (U.S.N.M. No. 20449).

Not all the protoreodont specimens from the Duchesne River beds, or attributed to the Beaver Divide conglomerate, are to be referred to *P. primus,* as the specimen (C.M. No. 12080) from near Baser Bend in the Uinta Basin, which Scott (1945, p. 233) referred to this species is, I believe, closer to *Protoreodon pumilus annectens* in the premolars. The specimen (A.M. No. 22558) purported to be from the Beaver Divide conglomerate, which Scott also included in this species, is rather immature and exhibits no permanent premolars. The molars in this are typically protoreodont with distinctly selenodont cusps, very distinct protoconules, and a size close to *P. pumilus.* The species represented is not clearly evident. The type of *Protoreodon tardus* is also stated to be from the Beaver Divide conglomerate. The differences between molars of it and A.M. No. 22558 are slight, but the *P. tardus* type strangely enough would appear to be closer to *Protoreodon pumilus* ss. than to *P. primus.*

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Protoreodon primus,* C.M. NO. 11893

Length of upper cheek tooth series, C (at alveolus)-M^3, inclusive	73.8*a*
Length of upper cheek tooth series, P^1-M^3, inclusive	64.3*a*
Upper premolar series, P^1-P^4, inclusive	32.8
Upper molar series, M^1-M^3, inclusive	33.0*a*
C, anteroposterior diameter	6.0*a*
P^1, anteroposterior diameter: greatest transverse diameter	6.8 : 3.0*a*
P^2, anteroposterior diameter: greatest transverse diameter	8.8 : 3.9
P^3, anteroposterior diameter: transverse diameter*	8.3 : 6.2
P^4, anteroposterior diameter: transverse diameter	7.5 : 8.8
M^1, anteroposterior diameter: transverse diameter*	9.4*a* : 9.6*a*
M^2, anteroposterior diameter: transverse diameter	10.6 : 12.5*a*
Length of lower cheek tooth series, P_1 (at alveolus)-M_3, inclusive	70.0*a*
Lower premolar series, P_1 (at alveolus)-P_4, inclusive	34.4
Lower molar series, M_1-M_3, inclusive	35.5*a*
P_1, anteroposterior diameter: greatest transverse diameter	7.0 : 4.5
P_2, anteroposterior diameter: greatest transverse diameter	7.9 : 3.2
P_3, anteroposterior diameter: greatest transverse diameter	8.5 : 3.7
P_4, anteroposterior diameter: greatest transverse diameter	9.2 : 4.7
M_1, anteroposterior diameter: transverse diameter of talonid	8.3 : 6.2
M_2, anteroposterior diameter: transverse diameter of talonid	10.6*a* : ...
M_3, anteroposterior diameter: transverse diameter of trigonid	16.0*a* : 7.8*a*

a, Approximate.

* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

The rather interesting collection of artiodactyl remains obtained by Princeton at the Leota Ranch quarry includes several protoreodont specimens. These are of a form about as large as *P. p. annectens,* but the teeth, particularly those of the lower series, are distinctly narrower than in the Myton pocket series and are hence tentatively referred to *Protoreodon primus.* As previously noted, the Leota Ranch quarry horizon is regarded as later than that at Myton pocket, but earlier than Randlett.

PROTOREODON PETERSONI,[29] new species

Plate 7

Type.—Skull and jaws with complete dentition, and other skeletal portions, P.U. No. 14404.

Horizon and locality.—Uinta C, Myton pocket, Uinta Basin, Utah.

Specific characters.—A little smaller than *Protoreodon minor* but decidedly more progressive in the achievement of a selenodont dentition. P^2 and P^3 both with deuterocone posterior in position and with a small posterointernal basin. P^4 has a single primary cusp and highly selenodont deuterocone. The outer cusps of upper molars are more crescentic than in *P. minor,* having their outer walls smoothly concave with the ribs weak or indistinct. Parastyle of each is perhaps less outstanding laterally, mesostyle compressed, and the lateral cingulum less shelflike. Protoconule is weak on M^1, weak or absent on M^2, and usually absent on M^3. On some upper molars there is a spur extending anteriorly from about midway along anterior crest of the metaconule which may, particularly on M^3, join the posterior crest of the protocone. P_4 is much as in *Protoreodon pumilus* but in one specimen exhibits a small spur extending anterolingually into the talonid basin from about midway across the posterior wall. Inner cusps of the lower molars are less conical than in *P. paradoxicus,* with the outer walls more flattened and the stylids somewhat less pocketed or shelflike than in the larger protoreodonts.

Discussion.—In addition to the type there are three skulls, two of which are immature but remarkably complete with jaws and other skeletal portions, in the Princeton collections, Nos. 14401, 14402, and 14403, and four partial dentitions in the collections of the U. S. National Museum. All but one of the specimens are from Myton pocket. One of these, U.S.N.M. No. 20386, including the right maxilla and portions of both lower jaws, is from Leland Bench draw. In all instances the material is clearly separable from the *P. minor* material

[29] Named for O. A. Peterson. Illustrated also in Scott, 1937, fig. 232.

of Kennedy's Hole and Devil's Playground. Kennedy's Hole type specimen of *P. minor* would appear to be from a distinctly earlier horizon than the Myton pocket material. I have no doubt but that *P. petersoni* was derived from *P. minor* and that when more material of these small protoreodonts is found, presumably at intervening horizons, no clear-cut separation will be feasible and that, as in the sequence of large protoreodonts (*P. pumilus* and *P. pumilus annectens*), *P. petersoni* may come to be regarded as an advanced variant of *P. minor*. At present, however, it would appear that *P. petersoni* has actually progressed somewhat farther from its antecedent, *P. minor,* than its contemporary *P. pumilus annectens* has from *P. pumilus* (sensu stricto).

In general, the skull of *Protoreodon petersoni* is like that of *P. pumilus*. Other than size, there is little in their form to distinguish them. It is noted, however, that the postorbital processes are better developed in *P. petersoni,* although they do not close behind the orbit

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Protoreodon petersoni*, P.U. NO. 14404

Length of upper cheek tooth series, C (at alveolus)-M^3, inclusive....	50.5
Length of upper cheek tooth series, P^1-M^3, inclusive................	42.0
Upper premolar series, P^1-P^4, inclusive............................	21.8
Upper molar series, M^1-M^3, inclusive..............................	21.5
C, anteroposterior diameter (at alveolus) : greatest transverse diameter	4.9 : 4.7
P^1, anteroposterior diameter : greatest transverse diameter...........	5.5 : 2.8
P^2, anteroposterior diameter : transverse diameter*..................	5.5 : 3.9
P^3, anteroposterior diameter : transverse diameter...................	5.6 : 5.0
P^4, anteroposterior diameter : transverse diameter...................	5.3 : 6.7
M^1, anteroposterior diameter : transverse diameter*..................	6.5 : 7.9
M^2, anteroposterior diameter : transverse diameter...................	7.9 : 9.8
M^3, anteroposterior diameter : transverse diameter...................	8.3 : 10.4
Length of lower cheek tooth series, P_1 (at alveolus)-M_3, inclusive....	46.4
Lower premolar series, P_1, (at alveolus)-P_4, inclusive...............	22.4
Lower molar series, M_1-M_3, inclusive..............................	24.3
P_1, anteroposterior diameter (at alveolus) : greatest transverse diameter	4.8 : 3.8
P_2, anteroposterior diameter : greatest transverse diameter...........	5.3 : 2.3
P_3, anteroposterior diameter : greatest transverse diameter...........	6.2 : 3.0
P_4, anteroposterior diameter : greatest transverse diameter...........	6.5 : 4.6
M_1, anteroposterior diameter : transverse diameter of talonid..........	6.2 : 5.0
M_2, anteroposterior diameter : transverse diameter of talonid..........	7.3 : 5.8
M_3, anteroposterior diameter : transverse diameter of trigonid.........	11.4 : 5.9

* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

as in *Merycoidodon.* I am unable to determine whether or not there was a preorbital fossa. The slight depression in this area on the type specimen may be due to crushing on one side, and there has been some restoration in plaster on the other. Of the remaining two skulls, one is too crushed at this point and the other suggests that if there was a preorbital fossa it was scarcely more than a very shallow depression.

Protoreodon petersoni comes nearer to being a possible ancestor of *Merycoidodon* than any members of the *P. parvus-P. pumilus* line. The modification of the paramere in molars of *P. petersoni,* unlike the *P. pumilus* line, is not so distinctly in the direction of *Agriochoerus* with rather small differences suggestive of *Merycoidodon.* P^4, moreover, has no tritocone, and the deuterocone tends to form a single crescent. Nevertheless, the lingual portion of the upper molars and the buccal portion of the lower molars are still agriochoerid in appearance. The posterior crest of the protocone is directed toward and not parallel with the anterior crest of the metaconule, and the anterior crest of the hypoconid is directed toward the posterior crest of the protoconid so as to leave a distinct basin external or buccal to the metastylid, quite unlike *Merycoidodon.*

Genus DIPLOBUNOPS Peterson, 1919

Type.—Diplobunops matthewi Peterson, 1919.

Discussion.—Diplobunops appears to be a distinctive and valid genus, although close to *Protoreodon.* It is characterized most noticeably by the somewhat lengthened rostrum, enlarged canines, and the widely expanded anterior extremity in comparison with *Protoreodon.* The premaxillae appear blunted forward with the third incisor alveolus distinctly more median to the enlarged canine than in *Protoreodon.* The rostrum is constricted posterior to the lateral expansion of the maxillae over the roots of the canines, and P^1 (in Uinta C and later forms) is isolated by diastemata from the canine and P^2. P^3 has a simple conical deuterocone with little or no tendency toward the development of a posterointernal basin. In P^4 the primary cusp in an unworn state does not appear to be twinned, but two generally prominent ridges on the lingual side of this cusp converge toward the apex so that moderate wear may produce the illusion of twinning. The deuterocone on P^4 is comparatively conical although the anterolaterally and posterolaterally directed crests are well defined. The lower premolars, and the molars in both the upper and lower series, are very much like those in *Protoreodon;* however, the molars are distinctly less selenodont, buccally above and lingually below, than in

such advanced types as *Protoreodon p. annectens* or the small *Protoreodon petersoni.* The mesostyles, as noted by Peterson, may be divided and project anteroposteriorly, but do not project buccally nearly so much as in the more-selenodont forms of *Protoreodon.* Moreover, the molars are relatively wider transversely than in the *Protoreodon* material I have examined.

Diplobunops, like *Protoreodon,* is, of course, not closely related to the bothriodonts although there is some resemblance in molar form. The specialization of P_1 rather than C as the functional caniniform tooth, as well as other differences, indicates agriochoerid affinities. Neither is *Diplobunops* the ancestor of *Agriochoerus,* as certain of its specializations, such as the transversely expanded rostrum anteriorly, more nearly enclosed orbit, etc., together with its retention of a more-primitive cheek tooth dentition even in the Duchesne River beds, suggest aberrance.

DIPLOBUNOPS MATTHEWI [30] Peterson, 1919

Plates 10, 11, and 12

Synonyms.—*Diplobunops uintensis* Peterson, 1931.
Diplobunops ultimus Peterson, 1931.

Type.—Much fragmentary skeletal material, C.M. No. 2974, also including portions of maxillae and jaws with the upper teeth broken or missing, but with P_3, P_4, M_2, and M_3 represented in the lower series (originally designated as a paratype, C.M. No. 3394, but later recognized by Peterson as a part of the type).

Horizon and locality.—Near base of Uinta C, 6 miles east of Myton, Uinta County, Utah.

Discussion.—Peterson (1931a, p. 344) indicated that teeth in *Diplobunops matthewi* were approximately equal in size to those in the type of *"Protagriochoerus annectens."* Actually, the former are about 15 percent larger in such dimensions as may be compared. The preserved lower teeth are relatively much wider transversely than in referred *Protoreodon p. annectens* material in both the premolar and molar portions, and the lower jaws are conspicuously thicker. The type of *D. matthewi* exhibits the very large canine and isolation of P^1 by diastemata characterizing the genus.

I find nothing in the type skull of *Diplobunops uintensis* in comparison with the limited material of *D. matthewi* which would serve to distinguish the second species. Peterson apparently looked forward to the finding of additional material of *D. matthewi* in beds of lower

[30] Also illustrated in Peterson, 1919, pl. 38, and 1931a, figs. 1-9, pls. 19, 20.

Uinta C to justify his belief that *D. uintensis* from the middle part of Uinta C would turn out to be a distinct and more-advanced species. So far only a time interval represented by about 250 feet of Uinta sediments separates them, and until more useful evidence is forthcoming, I do not think *D. uintensis* should be recognized.

The skull belonging to the portion of a skeleton that Peterson named *Diplobunops ultimus* came from about 400 feet above the base of Uinta C and hence about 150 feet above the type of *D. uintensis.* The skull of *D. ultimus* is rather crushed transversely, and proportions relative to those of the type of *D. uintensis* are difficult to determine. As Peterson noted, the molars appear to be a little narrower transversely. The primary cusp of P^4 has a prominent anterolingual ridge, but this seems characteristic of *Diplobunops* and is certainly present in the *D. uintensis* type, *D. crassus,* and the Badwater *Diplobunops* specimens. Peterson noted the smaller size of the canines in *D. ultimus* and suggested that this, together with the smaller size of the skull, may be no more than a sexual character. Such differences as noted do not appear to be due to any transition or development in time, leading, for example, to *D. crassus,* so I am inclined to regard *D. ultimus,* as well as *D. uintensis,* as a synonym of *D. matthewi.* The nomen nudum, *Diplobunops leotensis* Peterson (1931b, p. 74), evidently refers to the type of *Diplobunops ultimus,* as the latter was found in the "Leota Ranch" area.

MEASUREMENTS IN MILLIMETERS OF DENTITIONS IN SPECIMENS OF *Diplobunops matthewi*

	C.M.[31] No. 3394 Type	C.M.[32] No. 11769	C.M.[33] No. 11801A
Length of upper cheek tooth series, C (at alveolus)-M^3, inclusive	100.0*a*	102.3	105.0*a*
Length of upper cheek tooth series, P^1-M^3, inclusive	85.0*a*	86.0	....
Upper premolar series, P^1-P^4, inclusive	45.2*a*	48.7*a*	48.0
Upper molar series, M^1-M^3, inclusive	39.3*a*	38.5*a*	39.5
C, anteroposterior diameter (at alveolus): greatest transverse diameter	10.1*a*: 9.9*a*	10.0*a*: 11.7*a*	10.0*a*:....
P^2, anteroposterior diameter: greatest transverse diameter	......	10.2*a*:....	9.2: 5.7
P^3, anteroposterior diameter: transverse diameter*	......	10.0*a*: 10.0*a*	9.8: 9.5

[31] Overall measurements on teeth of *D. matthewi* type taken at or interpreted from alveoli.

[32] Type of *D. uintensis.*

[33] Type of *D. ultimus.*

	C.M. No. 3394 Type	C.M. No. 11769	C.M. No. 11801A
P^4, anteroposterior diameter: transverse diameter	8.3*a*: 11.8*a*	9.0*a*: 12.4*a*	9.9: 12.2
M^1, anteroposterior diameter: transverse diameter*	......	......	12.2: 14.0
M^2, anteroposterior diameter: transverse diameter	......	13.5: 19.0*a*	14.4: 16.8
M^3, anteroposterior diameter: transverse diameter	......	14.3: 21.0	15.3: 17.7
		U.S.N.M. No. 20390	
Length of lower cheek tooth series, P_1-M_3, measured at alveoli	......	84.5	95.0*a*
Lower premolar series, P_1-P_4, measured at alveoli	......	41.5	51.0*a*
Lower molar series, M_1-M_3, measured at alveoli	45.7	43.3	43.4*a*
P_1, anteroposterior diameter (at alveolus): greatest transverse diameter	......	10.7: 8.0	......
P_2, anteroposterior diameter: greatest transverse diameter	......	......	8.3: 5.2
P_3, anteroposterior diameter: greatest transverse diameter	10.4: 6.6	11.7: 7.3	10.0*a*: 6.3
P_4, anteroposterior diameter: greatest transverse diameter	11.5*a*:....	......	10.0*a*: 7.8*a*
M_1, anteroposterior diameter: transverse diameter of talonid	......	......	......
M_2, anteroposterior diameter: transverse diameter of talonid	13.8: 9.9	12.8: 10.2	12.6: 10.0*a*
M_3, anteroposterior diameter: transverse diameter of trigonid	21.4: 9.7	20.2: 9.9	21.0: 10.0*a*

a, Approximate.
* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

DIPLOBUNOPS CRASSUS [34] Scott, 1945

Type.—Nearly complete skull, C.M. No. 2967.

Horizon and locality.—Randlett member of Duchesne River formation, 1 mile south of Baser Bend and ½ mile west of Green River in Utah.

Discussion.—This is evidently a valid and recognizable species. The skull of *Diplobunops crassus* is more massive and broader than those referred to *Diplobunops matthewi.* Also, the molar teeth and P^4 are appreciably larger, although in the anterior premolars this is

[34] Illustrated in Scott, 1945, pl. 4, fig. 3, and pl. 5, figs. 1, 1b.

not so evident. I do not, however, find that the deuterocone on P^3 is particularly small as noted by Scott. It seems better defined than in the specimen Peterson designated as the type of *Diplobunops uintensis*. The distinctly less-selenodont character of the teeth in comparison with the more-advanced forms among *Protoreodon* species is well shown in the type of *Diplobunops crassus*.

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Diplobunops crassus*, C.M. NO. 2967

Length of upper cheek tooth series, C (at alveolus)-M^3, inclusive...	110.0
Length of upper cheek tooth series, P^1-M^3, inclusive..................	94.3
Upper premolar series, P^1-P^4, inclusive..........................	59.6
Upper molar series, M^1-M^3, inclusive............................	46.7
C, anteroposterior diameter (at alveolus): greatest transverse diameter	9.5*a*: 8.5*a*
P^1, anteroposterior diameter: greatest transverse diameter..........	8.8: 4.0
P^2, anteroposterior diameter: greatest transverse diameter..........	10.6: 5.6
P^3, anteroposterior diameter: transverse diameter*.................	12.0: 10.0
P^4, anteroposterior diameter: transverse diameter..................	11.0: 13.8
M^1, anteroposterior diameter: transverse diameter*.................	13.6: 16.8
M^2, anteroposterior diameter: transverse diameter..................	15.7: 19.7
M^3, anteroposterior diameter: transverse diameter..................	17.5: 22.3

a, Approximate.
* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

DIPLOBUNOPS VANHOUTENI,[35] new species

Plates 8 and 9

Type.—Skull, mandible, and other associated skeletal portions, P.U. No. 14251.

Horizon and locality.—Uinta B, White River pocket, Uinta Basin, Uinta County, Utah.

Specific characters.—Size much smaller than *Diplobunops matthewi*. Upper canine and P_1 almost as large as in *D. matthewi*. No diastema between P^1 and P^2. P^4 with ridges on lingual wall of single primary cusp much subdued. Deuterocone of P^4 subcrescentic. Upper molars low crowned and transversely very broad, with well-developed styles and moderate ribs. Molar cusps somewhat conical appearing and but weakly crescentic. Lower jaw shallow and lower premolars relatively large and crowded, with P_3 and P_4 rather distinctly pocketed anterolingually. Lower molars with comparatively conical lingual cusps, and lingual styles moderately developed only on the metaconid.

[35] Named for Dr. Franklyn B. Van Houten.

Discussion.—Diplobunops vanhouteni would appear to fulfill in all respects the requirements for a stage ancestral to the upper Uintan species of *Diplobunops.* Moreover, it more closely resembles contemporary forms of *Protoreodon* than do the later representatives of *Diplobunops.* The skull is nearly the size of later materials referred to *Protoreodon pumilus,* distinctly smaller than *Diplobunops matthewi.* The teeth are in a stage of development comparable to that of *Protoreodon parvus,* though possibly somewhat more primitive in being perhaps lower crowned and more weakly crescentic. Its assignment to *Diplobunops,* however, is based on the large size of the caniniform teeth and their broad separation, although it should be noted that the procumbent appearance of anterior cheek teeth in the lower jaw, as seen in plate 9, may be largely due to crushing. Moreover, the upper molars are, as in *Diplobunops,* significantly broad transversely, and the low cusps are rather widely spaced across the crown. This is not fully evident in plate 8 as there is marked foreshortening of the trans-

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Diplobunops vanhouteni,* P.U. NO. 14251

Length of upper cheek tooth series, C (at alveolus)-M^3, inclusive....	78.5*a*
Length of upper cheek tooth series, P^1-M^3, inclusive..................	65.0*a*
Upper premolar series, P^1-P^4, inclusive..........................	34.0*a*
Upper molar series, M^1-M^3, inclusive............................	31.9
C, anteroposterior diameter (at alveolus): greatest transverse diameter	9.0*a*: 8.5*a*
P^1, anteroposterior diameter..	8.0*a*
P^2, anteroposterior diameter..	10.0
P^3, anteroposterior diameter..	9.0
P^4, anteroposterior diameter: transverse diameter*..................	8.0: 11.9
M^1, anteroposterior diameter: transverse diameter*..................	9.4: 12.2
M^2, anteroposterior diameter: transverse diameter..................	10.9: 14.4
M^3, anteroposterior diameter: transverse diameter..................	12.1: 16.0
Length of lower cheek tooth series, P_1 (at alveolus)-M_3, inclusive...	70.9
Lower premolar series, P_1 (at alveolus)-P_4, inclusive...............	35.4
Lower molar series, M_1-M_3, inclusive............................	36.1
P_1, anteroposterior diameter: greatest transverse diameter (at alveolus)	9.2: 6.5
P_2, anteroposterior diameter: greatest transverse diameter...........	9.5: 3.7
P_3, anteroposterior diameter: greatest transverse diameter...........	10.1: 5.1
P_4, anteroposterior diameter: greatest transverse diameter...........	10.5: 6.2
M_1, anteroposterior diameter: transverse diameter of talonid..........	9.4: 7.8
M_2, anteroposterior diameter: transverse diameter of talonid..........	10.3: 8.4
M_3, anteroposterior diameter: transverse diameter of trigonid.........	17.1: 8.3

a, Approximate.
* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

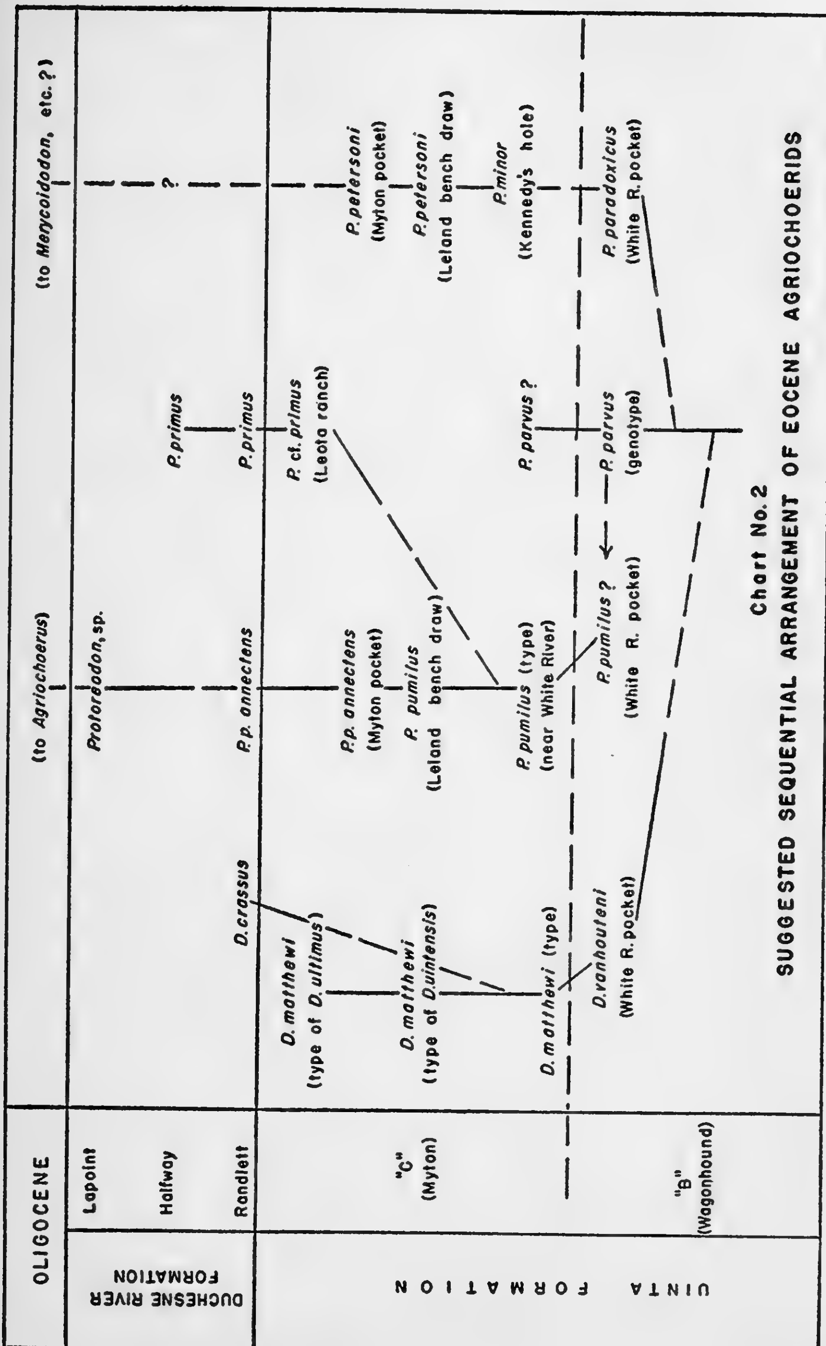

Chart No. 2

SUGGESTED SEQUENTIAL ARRANGEMENT OF EOCENE AGRIOCHOERIDS

verse diameter of these teeth as a consequence of the angle they are turned to the plane of the palate.

A feature not so evident in either *Protoreodon* or other *Diplobunops* material is the more noticeable pocketing or distinct basining of the anterolingual portion of the posterior lower premolars. In P_3 this may be largely due to crushing although it seems clear that there was a lingual rim along this portion of the tooth. In P_4, though likewise distorted by crushing, the basin appears more clearly defined.

OROMERYCIDAE, new family

The genera grouped in this very distinctive family include *Oromeryx, Protylopus, Camelodon, Malaquiferus,* and *Eotylopus.* It is characterized as distinct from the Camelidae in comprising comparatively short-snouted forms in which the teeth are more brachydont. The upper molars exhibit a protocone which bifurcates posteriorly, and the external ribs and mesostyle are strongly developed. The lower molars are peculiar in that the conical entoconid is distinctly isolated from the metaconid by a deep pocket which opens through a notch in the lingual wall of the tooth.

The name Oromerycidae is selected rather than one derived from *Protylopus* or *Eotylopus,* although these forms are better known, because *Oromeryx* is the oldest available name and there is a strong probability that *Protylopus* may eventually prove to be a synonym. Moreover, both *Protylopus* and *Eotylopus* give unwarranted and undesired suggestion of a relationship to the camelids.

The oromerycids would appear to be camelids in certain respects, particularly in the character of the lower premolars, the scarcely emphasized canines, and the procumbent lower incisors. In the premolars there are points of resemblance to the leptotragulids as well, but the first premolar below is not caniniform. The molars, usually considered to be the more-conservative structures, are highly distinctive and raise considerable doubt as to camelid as well as leptotragulid affinities of this group. Although Scott (1940) called attention to the many noncamelid-like structures and appearances of the *Eotylopus* skull and skeleton, he, unlike Matthew (1910), placed it in the Camelidae. Actually, *Eotylopus* is superficially more camel-like than *Protylopus,* but the resemblance is in characters which may be of no more than adaptive significance. It seems clearly evident that certain of the similarities are to be accounted for by convergence, and the basic relationship of the oromerycids is not so close to the camelids as the adaptive parallelism shown in the later form tends to suggest.

For example, I^3 in *Eotylopus* has become the caniniform tooth as in *Poëbrotherium,* whereas in *Protylopus* I^3 has not yet surpassed the canine in importance.

Matthew, with specific reference to *Eotylopus,* was inclined to stress lateral relationships in these primitive groups, but grouping *Eotylopus* and its allies with the leptrotragulids with their more advanced selenodont dentition seems less clearly indicated. One could perhaps make a better case for a not too remote relationship between the poëbrotherines and the leptotragulids, or between the oromerycids and the agriochoerids.

Genus OROMERYX Marsh, 1894

Type.—Oromeryx plicatus Marsh, 1894.

Discussion.—Oromeryx was the third of the Uintan artiodactyls that Marsh named in 1877 but which remained nomina nuda until their description and type designation in 1894. Marsh regarded *Oromeryx* as a cervid, but in subsequent references it has been considered as a hypertragulid. Peterson (1919) included *Oromeryx* with *Leptoreodon* and *Leptotragulus* in the Hypertragulidae, but noted certain resemblances to *Protylopus.* Direct comparison of the type materials of *Oromeryx* and *Protylopus* reveals that there is very little of significance distinguishing them.

Marsh's illustration (1894, fig. 23) of the type specimen of *Oromeryx plicatus* is, as Peterson noted, a composite of the two sides, and there are a number of inaccuracies in the drawing. The position of P^3 is shown as two alveoli. This tooth is actually broken off level with the palate, and the root portion is a single three-lobed structure, which clearly divided into at least a fore-and-aft root within the maxilla. The third lobe in a position supporting the deuterocone portion of the tooth may well have had a separate root, but if not the posterior root was evidently very broad and bilobed. P^4 is shown as a simple bicuspid tooth whereas, in fact, the crest of the deuterocone posteriorly divides the basin of the talon, leaving a deep and prominent pocket posteriorly closed by the raised cingulum, quite as in the *Protylopus petersoni* type specimen. Moreover, there are strong plications on the posterior portion of the external surface of this tooth (probably also on the anterior extremity of this surface as well), variously developed in *Protylopus petersoni.* The external styles and ribs of the upper molars are much more strongly developed, as Peterson noted, than the illustration shows, and the posterior portion of the protocone is strongly bifurcate, extending a crest

toward the metaconule and a rounded lobe toward the cleft between paracone and metacone. There is no indication of the latter character in Marsh's illustration.

The highly rugose or plicate character of the enamel in *Oromeryx* is well shown in the median valleys, and somewhat better on the lingual than on the labial surfaces. The crests, where unworn, are serrate, and the portions of a lingual cingulum exhibited are highly cuspate, particularly between the protocone and metaconule and as it is carried part way around the metaconule. The plicate character of the enamel is not peculiar to *Oromeryx* but is likewise highly developed on most *Protylopus* material of the Uinta B stage and on teeth of the Badwater form, *Malaquiferus.*

Perhaps the significant features of *Oromeryx,* if *Protylopus* is to be regarded as distinct, lie in the relative elongation of the teeth, anteroposteriorly, along the outer surface and the distinctly narrower posterior portion in comparison with the anterior width of the upper molars. The latter character was noted by both Scott and Peterson, but their comparisons were made with various leptomerycids. This distinction is somewhat emphasized by the incompleteness of the teeth in the *Oromeryx plicatus* type and, moreover, is less noticeable when viewed with materials of *Protylopus petersoni.*

OROMERYX PLICATUS [36] Marsh, 1894

Plate 15, figures 1-2

Type.—Right maxillary fragment with P^4 and the lingual portions of M^1-M^3; left maxillary fragment with M^3 and the labial portion of M^2, Y.P.M. No. 14571.

Horizon and locality.—Uinta B, mouth of White River (determined from Marsh's notes pertaining to collection No. 1057), Uinta Basin, Utah.

MEASUREMENTS IN MILLIMETERS OF DENTITION IN SPECIMENS OF *Oromeryx plicatus*

	Y.P.M. No. 14571 Type
Length of upper cheek tooth series, anterior margin of alveolus for P^3 to posterior margin of M^3	34.8
Upper molar series, M^1-M^3, inclusive	23.5
P^4, anteroposterior diameter : transverse diameter*	... : 5.7
M^1, anteroposterior diameter : transverse diameter*	7.4a : ...
M^2, anteroposterior diameter : transverse diameter	8.3 : ...
M^3, anteroposterior diameter : transverse diameter	8.8 : 9.3

[36] Also illustrated in Marsh, 1894, fig. 23.

	U.S.N.M. No. 20391
Length of lower cheek tooth series, anterior margin of alveolus for P_3 to posterior margin of M_3	40.3*a*
Lower molar series, M_1-M_3, inclusive	26.1*a*
M_1, anteroposterior diameter: transverse diameter of talonid	7.0: 4.7
M_2, anteroposterior diameter: transverse diameter of talonid	7.9: 5.6
M_3, anteroposterior diameter: transverse diameter of trigonid	11.2: 5.7*a*

a, Approximate.
* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

Discussion.—The specific characters of *O. plicatus* are not readily separated from those that have been cited as characterizing the genus, but in size the cheek teeth are slightly larger than in specimens referred to the better-known *Protylopus petersoni.*

Genus PROTYLOPUS Wortman, 1898

Type.—*Protylopus petersoni* Wortman, 1898.

Discussion.—*Protylopus* received marked attention by Wortman (1898) in his diagnosis of the genus and particularly by Scott (1899) in his study of the Uinta selenodonts. The skull, dentition, and other portions of the skeleton of *Protylopus petersoni,* as far as known, were compared in detail with the Oligocene *Poëbrotherium.* Except in Peterson's 1919 study of the Uinta fauna, however, I find no mention of comparisons made with Marsh's *Oromeryx plicatus.* Nevertheless, the similarity between the two in almost all details of the teeth is rather striking. The oversight may be due to the fact that the upper molars in all or nearly all the previously known *Protylopus petersoni* specimens were so badly worn or obscured that details of the pattern could not be readily discerned. Camelid affinities were diagnosed largely from the snout and anterior cheek teeth. It is important to note that the crown view of the upper cheek teeth shown by Scott (1899, pl. 2, fig. 6) is largely incorrect, or does not represent *Protylopus.* That of the lower teeth (fig. 7) may represent *Protylopus,* but M_3 is peculiar and M_2 is surely incorrect. Wortman's illustration (1898, fig. 4) of the lower teeth would appear to be more accurate.

Protylopus may well be a synonym of *Oromeryx,* as I suspect that additional material from Uinta B will demonstrate, but is tentatively retained as distinct on the basis of the more nearly rectangular appearance of the upper molars and their relatively shorter length anteroposteriorly. Serious doubt may be entertained as to the importance of these proportional differences, as material referred to *Protylopus petersoni* shows rather distinctive variations.

PROTYLOPUS PETERSONI[37] Wortman, 1898

Type.—Anterior portion of skull, right ramus of mandible, ulna and radius, A.M. No. 2076.

Horizon and locality.—Uinta C (according to Amer. Mus. labels, but probably low in C, or possibly Uinta B to judge by other collections), Uinta Basin, Utah.

Discussion.—In size *Protylopus petersoni* is only slightly smaller than *Oromeryx plicatus,* to judge by the limited amount of material known of each. P^3 is three rooted in the type, as appears to be true also in *O. plicatus;* however, the deuterocone is very weak and com-

MEASUREMENTS IN MILLIMETERS OF DENTITION IN SPECIMENS OF *Protylopus petersoni*

	A.M. No. 2076 Type	P.U. No. 14647
Length of upper cheek tooth series, C (at alveolus)-M^3, inclusive	45.0*a*	47.0*a*
Length of upper cheek tooth series, P^1-M^3, inclusive	41.0*a*	43.1*a*
Upper premolar series, P^1-P^4, inclusive	22.0*a*	21.7
Upper molar series, M^1-M^3, inclusive	21.0*a*	22.0*a*
C, anteroposterior diameter: greatest transverse diameter	2.7:...	2.9*a*:...
P^1, anteroposterior diameter: greatest transverse diameter	4.6:...	5.1:1.7
P^2, anteroposterior diameter: greatest transverse diameter	6.0:...	6.0*a*:...
P^3, anteroposterior diameter: transverse diameter*	5.8:3.8	6.5:2.7
P^4, anteroposterior diameter: transverse diameter	5.6*a*:5.7*a*	5.6:5.5
M^1, anteroposterior diameter: transverse diameter*	6.5*a*:...	6.6*a*:7.0*a*
M^2, anteroposterior diameter: transverse diameter	7.2:8.5	7.8:8.8
M^3, anteroposterior diameter: transverse diameter	8.3*a*:9.0	8.8:9.4
Length of lower cheek tooth series, C (at alveolus)-M_3, inclusive	50.5*a*	49.1*a*
Length of lower cheek tooth series, P_1-M_3, inclusive	......	46.2
Lower premolar series, P_1-P_4, inclusive	......	21.9
Lower molar series, M_1-M_3, inclusive	24.3	25.3
C, anteroposterior diameter: greatest transverse diameter	3.7*a*:...	3.7:2.0
P_1, anteroposterior diameter: greatest transverse diameter	......	3.7*a*:2.0
P_2, anteroposterior diameter: greatest transverse diameter	......	5.9:2.0
P_3, anteroposterior diameter: greatest transverse diameter	......	6.2:2.3
P_4, anteroposterior diameter: greatest transverse diameter	......	6.7:2.8
M_1, anteroposterior diameter: transverse diameter of talonid	6.0*a*:...	5.9:4.6
M_2, anteroposterior diameter: transverse diameter of talonid	7.2:...	7.0:5.8
M_3, anteroposterior diameter: transverse diameter of trigonid	11.8:5.8	12.5:6.0

a, Approximate.

* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

[37] Illustrated in Wortman, 1898, figs. 3-6; and Scott, 1899, pl. 2, figs. 5, 8, 9.

prises scarcely more than one of the several plications noted on the posterointernal wall of this tooth. In referred specimens of *P. petersoni* in the Princeton collection, from in or near the White River pocket, P^3 is clearly two rooted. One of these, P.U. No. 11222, is the excellent skull and jaws figured by Scott (1899, pl. 2, fig. 5). The teeth in this specimen are not fully exposed, as the jaws have not been separated from the skull, but enough can be seen of the upper molars on the left side to indicate that the protocone is noticeably bilobate posteriorly only on M^3. Moreover, the parastyle and mesostyle are surprisingly prominent and so deflected on M^2 and M^3 as to form conspicuous pockets with the paracone and metacone, respectively. Evidence of such a prominent stylar development is seen also on the rather well worn molars of P.U. No. 14647. The latter specimen likewise has a two-rooted P^3 but may have more strongly crenulated enamel as indicated by the highly serrate cingulum lingual to the metaconulid of M^3. These two specimens may represent a species or possibly a genus distinct from *Protylopus petersoni,* but too little is known of the dental characters of this species, and I suspect that the above Princeton specimens are no more than variants. The outline of the molars in occlusal view resembles *Protylopus* more closely than *Oromeryx.*

PROTYLOPUS? ANNECTENS [38] Peterson, 1919

Plates 13 and 14

Type.—Portions of the skull, lower jaws, and other parts of the skeleton, C.M. No. 2932.

Horizon and locality.—Uinta C, Myton pocket, Uinta Basin, Utah.

Discussion.—The type of *Protylopus? annectens* was not available for examination at Carnegie Museum, as it has been temporarily removed from the collections, or possibly lost. It is, however, represented by a magnificent array of nearly 200 skulls, maxillae, and jaws in the National Museum collection from a single quarry in Myton pocket. From Peterson's description, measurements, and information as to horizon and general locality, there appears to be no doubt as to the species represented by these specimens, but the generic reference is questioned as it is not certain as to whether this species should be referred to *Protylopus* or to *Oromeryx.* So long as *Protylopus* is regarded as distinct, it may be preferable to retain the species in that genus, as the outline of the upper molars more nearly corresponds to *P. petersoni.* However, the bifurcate character of the posterior crest of the protocone, so well developed in the Myton pocket

[38] Also illustrated in Peterson, 1919, fig. 15; pl. 37, fig. 14.

material, as it is also in *Eotylopus,* is certainly recognized only in *Oromeryx plicatus* of the earlier forms. In *Protylopus petersoni* this character, though suggested, is not clearly determined because of advanced wear in teeth of critical material.

Protylopus? annectens is further characterized by much greater size than either *P. petersoni* or *O. plicatus,* and the tooth enamel is comparatively smoother. P^3 has three distinct roots, but the deuterocone varies from weak to nearly as prominent as in P^4. The cingulum may be absent from the lingual margin of the upper molars but, if present, is usually developed around the protocone rather than the metaconule. However, a cusp (or cuspules) is present lingually between the protocone and metaconule as in the earlier forms.

MEASUREMENTS IN MILLIMETERS OF DENTITIONS IN REFERRED SPECIMENS OF *Protylopus? annectens*

	U.S.N.M. No. 20290	U.S.N.M. No. 20285
Length of upper cheek tooth series, P^1-M^3, inclusive	53.9	55.6
Upper premolar series, P^1-P^4, inclusive	26.3	27.3
Upper molar series, M^1-M^3, inclusive	28.5	28.8
C, anteroposterior diameter: greatest transverse diameter.	......	4.0 : 3.2
P^1, anteroposterior diameter: greatest transverse diameter.	5.7 : 2.5	6.2 : 2.4
P^2, anteroposterior diameter: greatest transverse diameter.	7.7*a* : 2.8	7.8 : 2.5
P^3, anteroposterior diameter: transverse diameter*	7.3 : 6.0	7.8 : 4.7
P^4, anteroposterior diameter: transverse diameter	6.7 : 7.2	6.9 : 7.1
M^1, anteroposterior diameter: transverse diameter*	9.0 : 9.3	8.8 : 8.9
M^2, anteroposterior diameter: transverse diameter	9.9 : 10.8	10.2 : 10.7
M^3, anteroposterior diameter: transverse diameter	11.0 : 12.0	11.0 : 12.0

	U.S.N.M. No. 20149	U.S.N.M. No. 20190
Length of lower cheek tooth series, C (at alveolus)-M_3, inclusive	69.0	64.3
Length of lower cheek tooth series, P_1-M_3, inclusive	63.0	60.2
Lower premolar series, P_1-P_4, inclusive	31.1	28.8
Lower molar series, M_1-M_3, inclusive	32.2	32.0
C, anteroposterior diameter: greatest transverse diameter.	4.0 : 2.8	4.3 : 2.8
P_1, anteroposterior diameter: greatest transverse diameter.	4.8 : 2.5	5.3 : 2.5
P_2, anteroposterior diameter: greatest transverse diameter.	8.0 : 2.5	6.6 : 2.3
P_3, anteroposterior diameter: greatest transverse diameter.	8.5 : 3.0	7.8 : 2.5
P_4, anteroposterior diameter: greatest transverse diameter.	8.1 : 4.2	7.7 : 3.5
M_1, anteroposterior diameter: transverse diameter of talonid	8.4 : 5.6	8.5 : 5.6
M_2, anteroposterior diameter: transverse diameter of talonid	9.8 : 6.1	9.9 : 6.3
M_3, anteroposterior diameter: transverse diameter of trigonid	14.8 : 6.8	14.5 : 6.8

a, Approximate.
* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

The lower dentition of *Protylopus? annectens* is characterized by a small but distinct metaconid on the posterointernal crest of P^4. The entoconid of the lower molars is conical as in *Protylopus petersoni,* and likewise the valley between the entoconid and hypoconid is open lingually through a small pocket formed by the anterior crest of hypoconid and a metastylid crest on the posterior surface of the metaconid. However, the anterior surface of the metaconid is different in that it is smoothly conical and lacks the anterior spur or crest which joins the anterior wing of the protoconid in the earlier form. In *P.? annectens* the parastylid or anterior wing of the protoconid swings widely forward around the metaconid so that the valley between the metaconid and protoconid is also open lingually. In *P. petersoni* and in lower molars believed to represent *Oromeryx plicatus,* this valley is closed forward and an anterior cingulum is carried around the tooth, rising on the lingual side of the metaconid so as to form a small pocket on the anterolingual surface of this cusp. It is further noted that a marked hypoconulid is developed on the posterior extremity of the crest from the hypoconid in M_1 and M_2, perhaps better defined than in the earlier forms, and the lingual cusp on the hypoconulid of M_3 has nearly or entirely lost its identity in the horseshoe-shaped crest of the hypoconulid lobe.

Genus CAMELODON Granger, 1910

Type.—Camelodon arapahovius Granger, 1910.

Discussion.—The teeth in this form, as far as can be determined considering the advanced wear exhibited in the only known specimen, are rather like those in *Protylopus,* but with smoother enamel. The principal character distinguishing *Camelodon* is the marked diastema between P_2 and P_3. *Camelodon* would appear to represent an aberrant stem within the Oromerycidae, not ancestral to *Eotylopus.* It should be noted, moreover, that the diastema in the lower premolar series of *Poëbrotherium* is anterior to P_2.

CAMELODON ARAPAHOVIUS [39] Granger, 1910

Type.—Left ramus of mandible with P_2-M_3, A.M. No. 14604.

Horizon and locality.—Uintan equivalent of the Wagonbed deposits on Beaver Divide, Fremont County, Wyo.

Discussion.—In size *Camelodon arapahovius* is about intermediate between *Protylopus petersoni* and *Protylopus? annectens.* Neither of

[39] Illustrated in Granger, 1910, fig. 4; and Scott, 1945, pl. 2, fig. 2.

these forms, however, shows any tendency toward a diastema in the premolar series as long as that in *C. arapahovius*. The jaw, moreover, appears to be relatively slender, taking into consideration its maturity as evidenced by tooth wear.

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Camelodon arapahovius*, A.M. NO. 14604

Length of lower cheek tooth series, P_2-M_3, inclusive	51.0
Lower molar series, M_1-M_3, inclusive	27.1
P_2, anteroposterior diameter : greatest transverse diameter	6.4 : 2.0
P_3, anteroposterior diameter : greatest transverse diameter	6.7 : 2.3
P_4, anteroposterior diameter : greatest transverse diameter	7.0 : 2.9
M_1, anteroposterior diameter : transverse diameter of talonid	6.8 : ...
M_2, anteroposterior diameter : transverse diameter of talonid	8.3 : 5.7
M_3, anteroposterior diameter : transverse diameter of trigonid	12.8 : 5.3

MALAQUIFERUS,[40] new genus

Type.—Malaquiferus tourteloti, new species.

Generic characters.—Orbit large and cranial portion of skull elongate. Enamel of cheek teeth highly rugose. P^4 without labially directed styles. External styles of upper molars weak but ribs outstanding. Upper molars nearly rectangular, transversely elongate, and not oblique. M^2 and M^3 of equal size. Protocone strongly bilobate posteriorly, at least in M^3.

Discussion.—Malaquiferus is clearly related to *Oromeryx* and *Protylopus,* but differs rather noticeably in the striking shift in emphasis from styles to ribs in the upper molars. These teeth are nearly rectangular, transversely elongate, and not so oblique as in *Oromeryx*. There is much less disparity in size between succeeding molars in *Malaquiferus* so that M^3 is relatively much smaller than in *Oromeryx* or *Protylopus,* being scarcely distinguished from M^2 in size and form. There appears to be no cingulum around the lingual margin of the protocone and metacone in any of the molars, although there is a prominent style or pillar lingually between these cusps in each. An additional feature noted is the comparatively large orbit and more elongate cranial portion of the skull than in *Protylopus*. *Malaquiferus* bears a strong resemblance to *Oromeryx,* and evidently to *Protylopus,* in the distinctly rugose tooth enamel and in the bilobate character of the posterior portion of the protocone in the upper molars.

[40] From Latin *malus,* bad; *aqua,* water; and *ferus,* wild animal. In allusion to its occurrence in the Badwater region.

MALAQUIFERUS TOURTELOTI,[41] new species

Plate 16

Type.—Greater part of skull with P^4-M^3, inclusive, U.S.N.M. No. 20588.

Horizon and locality.—Uintan deposits in sec. 11, T. 39N., R. 92 W., 1½ miles northeast of east fork of Dry Creek, Fremont County, Wyo.

Specific characters.—*Malaquiferus tourteloti* is comparable to *Protoreodon petersoni* in size of teeth, although the cranial proportions indicate a form somewhat greater in size. Other specific characters are not distinguished from those of the genus. The lower teeth are not known.

Discussion.—The type specimen of this rather unusual oromerycid was found by Harry A. Tourtelot, of the U. S. Geological Survey, in upper Eocene deposits exposed along the northern margin of the Wind River Basin, not far from and possibly equivalent in age to the fossiliferous exposures along the south side of Badwater Creek west of Badwater P. O. Further search of the exposures in the vicinity of the *Malaquiferus* occurrence for confirming evidence as to the age of the beds has produced remains of *Eomoropus*, cf. *amarorum.*

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Malaquiferus tourteloti*, U.S.N.M. NO. 20588

Length of preserved portion of upper cheek tooth series, P^4-M^3, inclusive	27.1
Upper molar series, M^1-M^3, inclusive	21.7
P^4, anteroposterior diameter : transverse diameter*	5.8 : 6.5
M^1, anteroposterior diameter : transverse diameter*	6.8 : 7.8
M^2, anteroposterior diameter : transverse diameter	7.4 : 8.8
M^3, anteroposterior diameter : transverse diameter	7.5 : 9.0

* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

Family CAMELIDAE Gray, 1821

Subfamily POËBROTHERIINAE Zittel, 1893

Attention was early directed to the possibility of camelids occurring in the Eocene of North America when Scott in 1889 suggested that *Leptotragulus* was closely allied to *Poëbrotherium* and belonged in the Tylopoda. This genus, however, is now regarded as a leptomerycid. Some time later (1898), Wortman described *Protylopus,*

[41] Named for Harry A. Tourtelot.

which was generally accepted as camelid, along with certain other Eocene forms now also included in other families. Subsequent studies have included description of *Camelodon* by Granger in 1910, here assigned along with *Protylopus* to the Oromerycidae, and description of the Duchesnean *Poabromylus* by Peterson in 1931, which I believe should be regarded as a leptomerycid, closely related to *Leptoreodon*. The new form *Poëbrodon,* the description of which follows, thus would seem significant as perhaps the first true camelid to be known from the Eocene.

Discovery of the rather limited material representing *Poëbrodon* has given new evidence as to the phylogenetic arrangement of certain of the Eocene selenodonts and has further emphasized the necessity for designating the new family Oromerycidae. *Protylopus* was early looked upon, particularly by Wortman (1898) and Scott (1899), as being in an ancestral position within the Poëbrotheriinae, although Matthew (1910) suggested that this relationship applied only to the descent of *Eotylopus.* Matthew went still further and excluded *Protylopus* and *Eotylopus* from the Camelidae and suggested that *Poëbrotherium* was derived from "an advanced contemporary (to *Protylopus*) genus of more northern habit." Peterson, like Scott, retained *Protylopus* in the Camelidae but agreed with Matthew that the ancestry of *Poëbrotherium* was to be sought "in some more advanced contemporary genus." It was evident, however, that he thought this would be found in the Uinta Basin; a prediction that has been made good. Scott (1945), however, remained convinced that *Protylopus* gave rise to *Poëbrotherium* as well as to *Eotylopus.*

Discovery of *Poëbrodon,* distinctly precocious, now furnishes the form, in support of Matthew's and Peterson's views, that completely anticipates *Poëbrotherium* in its combination of characters, as far as known. It likewise gives further evidence of the separateness of the oromerycids from the camelids.

POËBRODON,[42] new genus

Type.—Poëbrodon kayi, new species.

Generic characters.—Teeth like *Poëbrotherium* but shorter crowned. Anteroposteriorly much-compressed styles of upper molars slightly more outstanding. Weak metastylid flexure on lingual wall of lower molars, and lingual surface of metaconid and entoconid slightly more convex than in *Poëbrotherium.* Hypoconulid lobe of M_3 with lingual portion less reduced than in *Poëbrotherium.*

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[42] From Greek πόη (πόα), grass; βρόω, to eat; and 'οδών, tooth.

Discussion.—As has been noted in the previous discussion, discovery of such a form as *Poëbrodon* has been long anticipated. The most significant information to come from this find, however, is the demonstration that the Uintan stage of development is strikingly *Poëbrotherium*-like. Except for the more-brachydont teeth and only slightly more-noticeable styles of the molars, *Poëbrodon* is scarcely more than a very small *Poëbrotherium.* The upper molars of *Poëbrodon* do resemble *Leptomeryx,* but the parastyles and mesostyles are more compressed, the ribs flatter, and the transverse width of the teeth, particularly of M^1, is very much less. Moreover, there is evidence for a very strong posteriorly directed style from the metacone of M^3.

The poëbrotherine character of the lower molars is possibly even more striking. The lingual wall of these teeth, however, is somewhat less flattened, as noted in the slight flexure in early wear at about the position of a metastylid, and in the somewhat more emphasized bilobate appearance resulting from convexities about the metaconid and entoconid, respectively. Nevertheless, the anterior and posterior columns of these teeth, as in *Poëbrotherium,* are more distinctly separate from one another than, for example, in the leptomerycids. This effect of separate columns results from the early union of the flattened metaconid with the anterior and posterior crests of the protoconid, and similarly the union of the hypoconid crests with the entoconid. The important poëbrotherine distinction lies in the deflection of the anterior crest of the hypoconid inward and away from the posterior crest of the protoconid and its joining instead with the entoconid. The two columns are thus joined only along the lingual wall. In these respects the Poëbrotheriinae are distinct from the leptomerycids and differ fundamentally from the oromerycids.

POËBRODON KAYI,[43] new species

Plate 15, figure 3

Type.—Left maxillary fragment with M^1, M^2, and most of M^3, U.S.N.M. No. 20393.

Horizon and locality.—Uinta C, Myton pocket, Uinta Basin, Duchesne County, Utah.

Specific characters.—Teeth a little less than one-half the size of those in *Poëbrotherium wilsoni.*

Discussion.—In addition to the type upper dentition there are in the collection two portions of a left mandibular ramus, U.S.N.M. No. 20392, including M_3, M_2 with entoconid portion broken away,

[43] Named for Dr. J. LeRoy Kay.

and the posterior half of M_1. The lower jaw is from the same general locality as the type but is evidently not from the same individual, as the upper teeth show somewhat greater wear. It is rather surprising that two specimens of this rare form should show up about the same time, and fortunate that they complement one another in furnishing information on both the upper and lower molars. The anterior cheek teeth are not known, and no other skeletal portions in the collections have been recognized as pertaining to this form.

MEASUREMENTS IN MILLIMETERS OF DENTITIONS IN SPECIMENS OF *Poëbrodon kayi*

	U.S.N.M. No. 20393 Type
Length of upper molar series, M^1-M^3 (posterior margin of root), inclusive	20.2
M^1, anteroposterior diameter : transverse diameter*	6.3 : 5.3
M^2, anteroposterior diameter : transverse diameter	7.0 : 6.7
M^3, anteroposterior diameter : transverse diameter	7.7*a* : 6.8*a*

	U.S.N.M. No. 20392
M_1, transverse diameter of talonid	4.4
M_2, anteroposterior diameter : transverse diameter of talonid	7.0*a* : 4.8*a*
M_3, anteroposterior diameter : transverse diameter of trigonid	10.7 : 5.0

a, Approximate.
* Measurements of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

Family LEPTOMERYCIDAE Scott, 1899

Subfamily Leptotragulinae Zittel, 1893

The reasons for separating the leptotragulines from Hypertragulidae and including them tentatively with the leptomerycines in a separate family have been discussed above under the Hypertragulinae. Such an arrangement seems preferable to including the leptotragulids in the Camelidae, as Wortman (1898), Matthew (1903, p. 224), and Scott (1899) were inclined to do.

Attention is also again directed to the conclusion that *Oromeryx,* generally included with the leptotragulids, does not represent this subfamily but belongs in a distinct family. *Oromeryx* is clearly related to *Protylopus* and should not be grouped either with the hypertragulids or the leptotragulids. Moreover, *Poabromylus,* which Peterson described as a camelid, does not appear to present characters of significance other than size, suggesting the Camelidae, and seems to be more closely related to the leptotragulines. Its premolars, though large,

rather suggest *Leptoreodon* and the molars, though relatively high crowned, are of a *Leptoreodon-Leptotragulus* type.

The leptotragulids appear, with one exception, to be the only Eocene artiodactyls to have early developed a simple and nearly complete selenodont structure in the protomerous portion of the molars. The protocone and metaconule of the upper molars and the protoconid and hypoconid of the lower molars in the Uintan leptotragulines are simple crescentic structures without important bifurcations, and free, except in advanced wear, from the paramere, although the posterior crest of the hypoconid joins or forms a lingually placed hypoconulid. It is noteworthy that the posterior crest of the protocone and the anterior crest of the metaconule are directed more toward the saddle midway in the paramere rather than as *Protoreodon.* The exception noted above is in the precocious *Poëbrotherium*-like molars of *Poëbrodon.* Here the selenodonty is advanced but of a different character, in which an early union is established between the crests of the inner and outer cusps.

Genus LEPTOTRAGULUS Scott and Osborn, 1887

Synonym.—Parameryx Marsh, 1894.

Type.—Leptotragulus proavus Scott and Osborn, 1887.

Discussion.—Parameryx and *Leptotragulus* have been considered synonymous since 1894 when Marsh furnished a description of *Parameryx.* Later, when Wortman (1898) reviewed the characters, he concluded that the form represented was a tylopod, but in citing the name gave priority to *Parameryx. Parameryx,* like *Eomeryx* and *Oromeryx,* was named by Marsh in an address published in 1877; however, these were without adequate description and no types were named at that time. They remained nomina nuda until 1894. Therefore, if *Parameryx* and *Leptotragulus* are identical, *Leptotragulus,* of course, has priority. It should be noted, however, that since the molars of *Leptotragulus* and *Leptoreodon* are so much alike, and the teeth belonging to the type material of *Parameryx laevis* consist only of a few molars, there is perhaps a possibility, not too remote, that the synonymy adopted here is incorrect and that *Parameryx* and *Leptoreodon* are synonymous, in which case *Parameryx* would be the older term. The nature of the *Parameryx laevis* material is highly unsatisfactory so that preservation of the status quo is much to be desired.

The genus *Leptotragulus* is distinguished from *Leptoreodon* principally on the basis of the premolars. The difference is perhaps less noticeable in the upper premolars although P^2 and P^3 show evidence

of a better-developed tritocone than in *Leptoreodon.* In the lower jaws both P_3 and P_4 have an anterolingually directed crest from the protoconid, but in *Leptotragulus* the anterior extremity is more sharply flexed with a better-defined parastylid. A posteroexternal crest extends from the protocone, then swings inward forming the posterior crest of the heel. A posterointernal crest extends posteriorly and only slightly inward from the apex of the protoconid but terminates before reaching the posterior crest, leaving the talonid basin broadly open lingually. In some material of *Leptotragulus* this talonid basin of P_4 may be partially constricted medially by a slight plication from the posterointernal crest. In *Leptoreodon* there is a prominent metaconid posterointernal to the protoconid in P_4 and apparently also in P_3. Moreover, P_4 of *Leptoreodon* exhibits a usually distinctive, though variably developed, entoconid. In *Leptomeryx* the entoconid is well developed, and in P_4 joins the metaconid in early wear, but in P_3 joins the external crest well back of the protoconid. It may be further noted that the upper molars in *Leptomeryx* have a noticeably more oblique appearance than in the Eocene forms.

LEPTOTRAGULUS PROAVUS [44] Scott and Osborn, 1887

Plate 18, figure 1

Synonyms.—*Parameryx laevis* Marsh, 1894.
?*Parameryx sulcatus* Marsh, 1894.

Type.—Anterior portion of the left ramus of a mandible with P_4 and M_1, P.U. No. 11501.

Horizon and locality.—Uinta upper Eocene, "White River," Uinta Basin, Utah.

Discussion.—The gentoype, *Leptotragulus proavus,* is much the larger of the three Eocene species now recognized and is represented in collections by a relatively small amount of material. The premolars are relatively elongate and P_4 has a distinctive, lingually placed, nearly conical parastylid. The posterolingual crest swings slightly inward with a weak suggestion of a metaconid nearly halfway down its slope, and there is a slight plication from this crest directed toward the middle of the talonid basin. M_1 shows a prominent accessory cusp or pillar between the protoconid and hypoconid.

The cotype lower jaw material of *Parameryx laevis,* which exhibits part of M_1 and M_2, corresponds in all details to the M_1 in *L. proavus.*

The Chadron form *Leptotragulus profectus* Matthew, from Pipe-

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[44] Also illustrated in Scott, 1889, pl. 7, figs. 10, 10a.

stone Springs, is much larger than *L. proavus* but is surprisingly similar. It also bears a striking resemblance to *Protoceras*. I believe that a closer affinity is indicated here than with the camelids. *L. profectus* may be a connecting link between the Eocene *Leptotragulus* and later *Protoceras*. Possibly Cook's form *Pseudoprotoceras longinaris* is the same as Matthew's *L. profectus*. As yet only the upper dentition of one and the lower of the other have been described or illustrated.

MEASUREMENTS IN MILLIMETERS OF DENTITIONS IN SPECIMENS OF *Leptotragulus proavus*

	C.M. No. 10199
Length of upper cheek tooth series, P^3-M^1, inclusive	22.0
P^3, anteroposterior diameter : transverse diameter	8.0 : 6.0
P^4, anteroposterior diameter : transverse diameter	7.0 : 7.3
M^1, anteroposterior diameter : transverse diameter	7.4 : 10.1

	P.U. No. 11501 Type
Length of lower cheek tooth series, P_2-M_1, inclusive	27.7
P_2, anteroposterior diameter (at alveoli)	6.4
P_4, anteroposterior diameter : greatest transverse diameter	7.3 : 3.5
M_1, anteroposterior diameter : transverse diameter of talonid	7.4 : 5.5

LEPTOTRAGULUS MEDIUS [45] Peterson, 1919

Plate 17, figures 2, 3

Type.—Rostral portion of skull with upper dentition P^3-M^3, C.M. No. 2986.

Horizon and locality.—Uinta C, 6 miles east of Myton, Uinta Basin, Utah.

Discussion.—Peterson listed a lower-jaw portion with M_3 and certain limb fragments as belonging to the type. However, in the lower jaw the preserved tooth (probably M_2 but not M_3) is at the point of erupting and hence does not belong to the same individual as the rostrum. For this reason there may be some doubt as to which individual the limb fragments belong.

This species is represented in the collections of the U. S. National Museum by about 27 jaws and maxillae with teeth. All these are from Myton pocket and all but four from the *Protylopus* quarry.

The *Leptotragulus medius* material is a little less than four-fifths the size of *L. proavus*. The lower premolars are relatively less slender, and in P_4 the parastyle, though distinct, is not so nearly conical.

[45] Also illustrated in Peterson, 1919, pl. 37, figs. 1-4.

MEASUREMENTS IN MILLIMETERS OF DENTITIONS IN SPECIMENS OF *Leptotragulus medius*

	C.M. No. 2986 Type	U.S.N.M. No. 16549
Length of upper cheek tooth series, P^2-M^3, inclusive	......	34.5
Length of upper cheek tooth series, P^3-M^3, inclusive	31.0	29.3
Upper molar series, M^1-M^3, inclusive	20.4	19.5
P^2, anteroposterior diameter : transverse diameter*	......	5.5 : 3.4*a*
P^3, anteroposterior diameter : transverse diameter	5.8 : 4.6	5.8 : ...
P^4, anteroposterior diameter : transverse diameter	5.2 : 5.8	5.3 : 5.5
M^1, anteroposterior diameter : transverse diameter*	5.9 : 7.3	6.2 : 7.2
M^2, anteroposterior diameter : transverse diameter	7.2 : 8.7*b*	7.2 : 8.9*b*
M^3, anteroposterior diameter : transverse diameter	7.3 : 9.2*b*	7.3 : 8.9*b*

	U.S.N.M. No. 20361	U.S.N.M. No. 20365
Length of lower cheek tooth series, P_1 (at alveolus)-M_3, inclusive	......	48.0*a*
Length of lower cheek tooth series, P_2-M_3, inclusive	38.3	38.6*a*
Lower premolar series, P_1 (at alveolus)-P_4, inclusive	......	25.0*a*
Lower molar series, M_1-M_3, inclusive	23.0	23.4
P_1, anteroposterior diameter (at alveolus) : greatest transverse diameter	......	4.7 : 3.6
P_2, anteroposterior diameter	5.0	......
P_3, anteroposterior diameter : greatest transverse diameter	5.9 : ...	5.8 : 3.2
P_4, anteroposterior diameter : greatest transverse diameter	5.8 : ...	6.2 : 4.1
M_1, anteroposterior diameter : transverse diameter of talonid	6.1 : ...	6.1 : 5.2
M_2, anteroposterior diameter : transverse diameter of talonid	6.7 : ...	6.9 : 5.8
M_3, anteroposterior diameter : transverse diameter of trigonid	10.6 : ...	10.7 : 6.2

a, Approximate.
b, Margin of enamel lingually.
* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

LEPTOTRAGULUS CLARKI,[46] new species

Plate 17, figure 1

Type.—Right ramus of mandible with P_1 and P_3-M_3, U.S.N.M. No. 20378.

Horizon and locality.—*Protylopus* quarry, Myton pocket, 6 miles east of Myton, Uinta Basin, Utah.

Specific characters.—Size only a little smaller than *Leptotragulus medius* but with teeth relatively much more slender. P_3 and P_4 with posterior crests from protoconid less divergent.

[46] Named for Dr. John Clark.

Discussion.—In addition to the type, there were three other lower jaws and possibly a maxilla found representing this species in association with the bulk of the *Leptotragulus medius* material in the *Protylopus* quarry. Two of the lower jaws are immature and retain milk premolars along with the permanent molars. The referred maxilla has but three molariform teeth preserved.

The difference between *Leptotragulus clarki* and *L. medius* was not at first evident, but when measurements were taken of a series of lower dentitions, two size groups were clearly indicated. Upon more detailed examination further differences observed included relatively narrower teeth, particularly in the premolar region, and the fact that the two crests extending posteriorly from the apex of the protoconid in P_3 and P_4 were in consequence much less divergent than in *L. medius.* The single upper dentition, U.S.N.M. No. 20373, preserved shows that M^1 to M^3, if these teeth are correctly identified, though only a little shorter anteroposteriorly than in *L. medius,* are conspicuously narrower transversely. There is a possibility, however, that the first of these is Dp^4 rather than M^1, as suggested by advanced wear, in which case the specimen would represent a moderately large *L. medius.* Nevertheless, I have been unable to find evidence of a replacing P^4 beneath the position of the first tooth. It may be noted that Dp^4 in *Leptotragulus* material would appear to be an exact replica of M^1, though smaller, and the wear would be relatively more advanced in comparison with the tooth next posterior.

The *Leptotragulus* material in the Princeton collections, found associated with specimens of *Pentacemylus leotensis* and *Protoreodon,*

MEASUREMENTS IN MILLIMETERS OF DENTITION IN SPECIMENS OF *Leptotragulus clarki*

	U.S.N.M. No. 20378 Type	U.S.N.M. No. 20380
Length of lower cheek tooth series, P_1 (at alveolus)-M_3, inclusive	43.0*a*	......
Lower premolar series, P_1 (at alveolus)-P_4, inclusive	23.0*a*	......
Lower molar series, M_1-M_3, inclusive	20.3	20.1
P_1, anteroposterior diameter (at alveolus) : greatest transverse diameter	3.8 : 2.5	4.0*a* : 2.4
P_3, anteroposterior diameter : greatest transverse diameter	5.2 : 2.3	......
P_4, anteroposterior diameter : greatest transverse diameter	5.3 : 3.4	5.4 : 3.0
M_1, anteroposterior diameter : transverse diameter of talonid	5.6 : ...	5.5 : 4.4
M_2, anteroposterior diameter : transverse diameter of talonid	6.5 : ...	6.3 : 5.1
M_3, anteroposterior diameter : transverse diameter of trigonid	9.0 : 5.0	8.7 : 5.2

a, Approximate.

cf. *primus* at the Leota Ranch quarry, all appears to represent a smaller, more slender toothed species than *Leptotragulus medius* and may well represent *Leptotragulus clarki.*

Genus LEPTOREODON Wortman, 1898

Synonyms.—Merycodesmus Scott, 1898.
Camelomeryx Scott, 1898.

Type.—Leptoreodon marshi Wortman, 1898.

Discussion.—Merycodesmus and *Camelomeryx* were named by Scott in a paper presented before the Philosophical Society in March, 1898, but not published until April 15, 6 days after Wortman's paper that included the description of *Leptoreodon.* Careful comparison of the materials representing these three convinces me that only one form is represented.

The principal characters defining *Leptoreodon* have been discussed above in comparison with *Leptotragulus.* It has been noted that *Leptoreodon* is characterized as distinct from *Leptotragulus* essentially in the different development of the lower premolars. In these, notably P_3 and P_4, there is only a single crest immediately posterior to the apex of the protoconid, but in both these there is a distinct metaconid which is joined by a spur to the principal posterior crest at some position behind the protoconid. This arrangement generally leaves a prominent forward- and inward-facing groove between these cusps, particularly in P_4, which is rather unlike *Leptotragulus.* Moreover, there is generally a well-defined cusp at the posterointernal extremity of the posterior crest in the position of an entoconid in P_4 and possibly, though not clearly observed, in P_3. Also, the parastylid of these two teeth is not clearly distinguished on the anterior crest in *Leptoreodon.* In *Leptomeryx* the metaconid and entoconid are well developed, but in P_4 the metaconid is nearly opposite and joins the protoconid, and the large entoconid nearly or quite joins the metaconid. In P_3 the metaconid is weak and takes the form of a crest extending posteriorly from the protoconid. The entoconid usually does not join it but unites with the principal posterior crest about midway of its length. *Leptomeryx,* moreover, exhibits a well-developed parastylid on P_2 to P_4.

In the upper premolar series less of significance was observed, but P^4 in *Leptoreodon* appears broader transversely and the deuterocone preserves somewhat more of its identity as a cusp. In *Leptotragulus* the deuterocone is perhaps more selenodont, and P^2 and P^3 exhibit a better-developed tritocone.

Leptomeryx does not appear to have originated in either *Leptotragulus* or *Leptoreodon* but in some intermediate form possessing a combination of characters in part resembling one and in part the other. The upper dentition of *Leptomeryx* most nearly resembles that of *Leptotragulus* but the posterior portions of the lower premolars are not readily reconciled. Likewise, the lower premolars of *Leptoreodon* present an arrangement which is perhaps too differently specialized.

LEPTOREODON MARSHI [47] Wortman, 1898

Plate 18, figure 2

Synonyms.—Merycodesmus gracilis Scott, 1898.
Camelomeryx longiceps Scott, 1898.

Type.—Skull and both rami of mandible, A.M. No. 2064.

Horizon and locality.—Uinta formation, near White River, Uinta Basin, Utah.

Discussion.—Leptoreodon marshi corresponds rather closely in size to *Leptotragulus proavus.* The essential characteristics of the premolars have been described above in comparisons on a generic level. The molars may not be distinguishable from those in the larger species of *Leptotragulus.* In general, they are relatively broad and highly selenodont, lingually above and buccally below. The outer wall of the upper teeth has prominent ribs and styles and a cingulum is well developed. Internally, the cingulum may be heavy around the metaconule but is weaker or not defined lingual to the protocone. Between these cusps lingually there is a distinct pillar or accessory cuspule which, though variably developed, appears to be persistent. An equivalent cuspule is present between protoconid and hypoconid below. The lower molars, however, show less evidence of a cingulum, except on the anterior and posterior faces.

MEASUREMENTS IN MILLIMETERS OF DENTITIONS IN SPECIMENS OF *Leptoreodon marshi*

	A.M. No. 2064 Type	P.U.[48] No. 11225	P.U.[49] No. 11226
Length of upper cheek tooth series, C (at alveolus)-M^3, inclusive	58.0	64.0*a*	57.5
Length of upper cheek tooth series, P^1-M^3, inclusive	50.8	55.2*a*	51.5*a*
Upper premolar series, P^1-P^4, inclusive..	29.5	33.5*a*	31.0*a*

[47] Also illustrated in Wortman, 1898, fig. 1; and Scott, 1899, pl. 2, figs. 10-14; pl. 3, figs. 15, 16.

[48] Type of *Merycodesmus gracilis.*

[49] Type of *Camelomeryx longiceps.*

	A.M. No. 2064 Type	P.U. No. 11225	P.U. No. 11226
Upper molar series, M^1-M^3, inclusive....	23.0	22.5	21.9
C, anteroposterior diameter (at alveolus) : greatest transverse diameter...	4.5 : ...	5.4 : 3.2*a*	4.5 : 3.0
P^1, anteroposterior diameter : greatest transverse diameter	4.5 : ...	5.0 : ...	3.5 : ...
P^2, anteroposterior diameter : greatest transverse diameter	6.5 : ...	7.0*a* : ...	6.9 : 2.5
P^3, anteroposterior diameter : transverse diameter*	7.3*a* : ...	7.0*a* : 5.0*a*	7.0 : 6.0*a*
P^4, anteroposterior diameter : transverse diameter	6.2 : ...	5.3*a* : 7.0	... : 6.5*a*
M^1, anteroposterior diameter : transverse diameter*	7.0*a* : 8.5*a*	6.6*a* : 8.9	6.2 : 7.7
M^2, anteroposterior diameter : transverse diameter	8.0*a* : 10.0*a*	8.4*a* : 10.5	7.3 : 10.3
M^3, anteroposterior diameter : transverse diameter	8.6*a* : 11.0*a*	8.9 : 11.5	8.4 : 11.6

			U.S.N.M. No. 20397
Length of lower cheek tooth series, P_1 (at alveolus)-M_3, inclusive.........	58.0*a*	58.1	......
Lower premolar series, P_1 (at alveolus)-P_4, inclusive	31.5	32.3	......
Lower molar series, M_1-M_3, inclusive....	26.5	26.0	......
P_1, anteroposterior diameter (at alveolus)	4.5*a*	4.4	......
P_2, anteroposterior diameter : greatest transverse diameter	5.5*a* : 2.2*a*	5.0*a* : ...	......
P_3, anteroposterior diameter : greatest transverse diameter	7.2 : 2.5*a*	7.0 : 3.0	7.0*a* : ...
P_4, anteroposterior diameter : greatest transverse diameter	7.5 : ...	6.8 : 4.0	7.1 : 3.9
M_1, anteroposterior diameter : transverse diameter of talonid...............	7.0 : ...	6.6*a* : ...	6.8*a* : 5.4
M_2, anteroposterior diameter : transverse diameter of talonid...............	8.0 : ...	7.8 : 6.0	8.2 : 6.4
M_3, anteroposterior diameter : transverse diameter of trigonid..............	11.6 : ...	12.0*a* : 6.3	... : 6.8

a, Approximate.
* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

LEPTOREODON (HESPEROMERYX) EDWARDSI[50] **Stock, 1936**

Type.—An upper cheek tooth series, P^2 to M^3, inclusive, C.I.T. No. 1839.

[50] Illustrated in Stock, 1936, pl. 1.

Horizon and locality.—Upper Uintan, Sespe formation, Tapo Ranch or C.I.T. loc. 180, north side of Simi Valley, Ventura County, Calif.

Discussion.—*Leptoreodon* (*H.*) *edwardsi* is a little smaller than *Leptoreodon marshi,* but clearly belongs to *Leptoreodon* rather than *Leptotragulus* as Stock has shown. P^2 and P^3, though worn, show no evidence of a tritocone as in *Leptotragulus.* P^4 is transversely broad as in *Leptoreodon* but the deuterocone would appear to be perhaps somewhat less crescentic than in *L. marshi,* certainly less so than in *Leptotragulus.* The lower dentition belonging to C.I.T. No. 1840, designated as a paratype, shows advanced wear, but P_4 has a prominent, rounded metaconid. The bifurcation of the posterior crest posterointernally has also been noted in *P. marshi* material. The anterior crest, however, shows a somewhat more sharply flexed anterior extremity suggesting a distinct parastylid cusp as in *Leptotragulus,* although this is clearly not present in P_2 and P_3. The latter two teeth are slender, and P_2 as well as P_3 has a weak posterointernal crest rather than a distinct metaconid which joins the outer crest nearer the apex of the protoconid than is noted in *L. marshi* material.

MEASUREMENTS IN MILLIMETERS OF DENTITIONS IN SPECIMENS OF
Leptoreodon (*Hesperomeryx*) *edwardsi*

	C.I.T. No. 1839 Type
Length of upper cheek tooth series, P^2-M^3, inclusive	37.7*a*
Upper molar series, M^1-M^3, inclusive	21.3
P^2, anteroposterior diameter : transverse diameter*	6.3 : 3.1
P^3, anteroposterior diameter : transverse diameter	6.5 : 3.6
P^4, anteroposterior diameter : transverse diameter	5.7 : 6.3
M^1, anteroposterior diameter : transverse diameter*	6.3 : 8.2
M^2, anteroposterior diameter : transverse diameter	7.7 : 9.8
M^3, anteroposterior diameter : transverse diameter	8.0 : 10.0

	C.I.T. No. 1840
Length of lower cheek tooth series, P_2-M_3, inclusive	41.1
Lower molar series, M_1-M_3, inclusive	35.0
P_2, anteroposterior diameter : greatest transverse diameter	5.5 : 2.0
P_3, anteroposterior diameter : greatest transverse diameter	6.4 : 2.9
P_4, anteroposterior diameter : greatest transverse diameter	6.4 : 3.6
M_1, anteroposterior diameter : transverse diameter of talonid	6.3 : 5.2
M_2, anteroposterior diameter : transverse diameter of talonid	7.3 : 6.1
M_3, anteroposterior diameter : transverse diameter of trigonid	10.2 : 5.9

a, Approximate.
* Measurements of posterior upper premolars are taken anteroposteriorly across outer portion and transversely perpendicular to outer margin. Those of upper molars are taken anteroposteriorly perpendicular to anterior margin and transversely across anterior portion of tooth.

The upper molars of *L.* (*H.*) *edwardsi* show a somewhat less sharply flexed outer wall with less-prominent styles and ribs than observed in *L. marshi.* In the lower molars the lingual median cuspule is well developed and the cingulum appears to encroach somewhat farther lingually on the principal inner cusps, but this would not appear to be significant.

As Stock has indicated in his description of *Hesperomeryx,* the differences in the premolars between *Leptoreodon* (*H.*) *edwardsi* and *Leptoreodon marshi* are rather significant but probably not of full generic importance.

Genus **POABROMYLUS** Peterson, 1931

Type.—*Poabromylus kayi* Peterson.

Discussion.—*Poabromylus* was described by Peterson as a camelid and regarded as such by Scott (1945). I am convinced, however, regardless of its large size, that it is a leptotragulid. In the structure of the lower molars it more closely resembles the leptomerycids in general than it does either the oromerycids or Poëbrotheriinae. P_4 has a metaconid developed similarly but relatively not so large as in *Leptoreodon,* and the anterior crest in both P_3 and P_4 extends forward and inward as in *Leptoreodon* without the separate parastylid cusp noticed in the camelids. The heel of P_4 has a basin somewhat resembling that in *Protylopus,* but this portion of the tooth is much broader, as it is in *Leptoreodon.* The talonid portion of P_3 is slightly damaged posterointernally, but the posterior half of this tooth is not unlike the camelids; neither is it unlike *Leptotragulus* or even the Sespe subgenus *Hesperomeryx.*

Of more fundamental significance would appear to be the structure of the molars. In the lower series the inner wall is continuous as in both the leptotragulids and poëbrotherines, not deeply interrupted as it is in the oromerycids. On the other hand, the highly crescentic outer cusps have the leptotragulid pattern, not the oromerycid arrangement where the entoconid remains relatively isolated except in advanced wear, or the poëbrotherine arrangement where the separation of the two outer crests from each other is very distinct and a union is made primarily with the opposite inner cusp to form an irregular ellipse in both the trigonid and talonid portion. Moreover, the heel or hypoconulid portion of M_3 is quite like that characterizing *Leptoreodon* and *Leptotragulus* rather than the camelids.

The *Poëbrotherium*-like slenderness of the lower jaw attributed to *Poabromylus* cannot be verified, as the lower margin of the jaw of

the type of *P. kayi* is nowhere preserved; hence the profile given in Peterson's illustration may be misleading.

Poabromylus appears to be a valid genus most nearly resembling *Leptoreodon* but with premolars somewhat distinctive and both premolars and molars a little more hypsodont.

POABROMYLUS KAYI [51] Peterson, 1931

Type.—Left ramus of mandible with P_3 to M_3, inclusive, C.M. No. 11753.

Horizon and locality.—Lapoint member of Duchesne River formation, near *Teleodus* quarry, 11 miles west of Vernal, Uinta County, Utah.

Discussion.—The specific characters of *Poabromylus kayi* are not distinguished from those on a generic level, except that in size it is much larger than other known leptotragulids. So far this is the only Duchesnean artiodactyl which may be allocated to the Leptomerycidae.

MEASUREMENTS IN MILLIMETERS OF DENTITION IN TYPE SPECIMEN OF *Poabromylus kayi*, C.M. NO. 11753

Length of lower cheek tooth series, P_3-M_3, inclusive	51.9
Lower molar series, M_1-M_3, inclusive	35.5
P_3, anteroposterior diameter : greatest transverse diameter	8.8 : 4.0
P_4, anteroposterior diameter : greatest transverse diameter	8.8 : 5.1
M_1, anteroposterior diameter : transverse diameter of talonid	8.9 : 6.7*a*
M_2, anteroposterior diameter	10.7
M_3, anteroposterior diameter : transverse diameter of trigonid	16.5 : 8.8

a, Approximate.

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EXPLANATION OF PLATES

PLATE 1

Mytonomeryx scotti, new genus and species: Dorsal, lateral, and ventral views of skull and lateral view of left ramus mandible (U.S.N.M. No. 20401), type specimen. Natural size. Myton pocket, Uinta Basin, Utah.

PLATE 2

Above, *Pentacemylus progressus* Peterson: Left maxilla (U.S.N.M. No. 20435), occlusal view of teeth. Approximately three times natural size. Myton pocket, Uinta Basin, Utah.

Below, *Mytonomeryx scotti*, new genus and species: Skull (U.S.N.M. No. 20401), type specimen, occlusal view of teeth. Approximately three times natural size. Myton pocket, Uinta Basin, Utah.

PLATE 3

Fig. 1. *Mytonomeryx scotti*, new genus and species: Left ramus of mandible (U.S.N.M. No. 20401), type specimen, occlusal view of teeth. Approximately one and one-half times natural size. Myton pocket, Uinta Basin, Utah.

Figs. 2, 3. *Pentacemylus progressus* Peterson: 2, Left ramus of mandible (U.S.N.M. No. 20437), occlusal view of teeth; 3, left ramus of mandible (U.S.N.M. No. 20438), lateral view. Approximately one and one-half times natural size. Myton pocket, Uinta Basin, Utah.

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PLATE 4

Protoreodon pumilus (Marsh): Skull and mandible (U.S.N.M. No. 20590), lateral view. Natural size. Leland Bench draw, Uinta Basin, Utah.

PLATE 5

Protoreodon pumilus (Marsh): Above, skull and mandible (U.S.N.M. No. 20590), dorsal and lateral views. Approximately two-thirds natural size. Leland Bench draw, Uinta Basin, Utah. Below, upper and lower dentitions (U.S.N.M. No. 20352), occlusal view. Natural size. Myton pocket, Uinta Basin, Utah.

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PLATE 8

Diplobunops vanhouteni, new species: Skull (P.U. No. 14251), type specimen, ventral view. Natural size. White River pocket, Uinta Basin, Utah.

PLATE 9

Diplobunops vanhouteni, new species: Mandible (P.U. No. 14251), type specimen, occlusal view. Natural size. White River pocket, Uinta Basin, Utah.

PLATE 10

Diplobunops, cf. *matthewi* Peterson: Skull (U.S.N.M. No. 20303), dorsal view. Natural size. Badwater upper Eocene, Wind River Basin, Wyoming.

PLATE 11

Diplobunops, cf. *matthewi* Peterson: Skull (U.S.N.M. No. 20303), lateral view. Natural size. Badwater upper Eocene, Wind River Basin, Wyoming.

PLATE 12

Diplobunops, cf. *matthewi* Peterson: Skull (U.S.N.M. No. 20303), ventral view. Natural size. Badwater upper Eocene, Wind River Basin, Wyoming.

PLATE 13

Protylopus? annectens Peterson: 1, 2, Skull (U.S.N.M. No. 20263), lateral and ventral views. 3, Skull (U.S.N.M. No. 20261), ventral view. Natural size. Myton pocket, Uinta Basin, Utah.

PLATE 14

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Figs. 4, 5. Cf. *Oromeryx plicatus* Marsh: 4, Left ramus of mandible (U.S.N.M. No. 20391), occlusal and lateral views. 5, Right ramus of mandible (U.S.N.M. No. 20391), occlusal view. Approximately two times natural size. White River pocket, Uinta Basin, Utah.

PLATE 16

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PLATE 17

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PLATE 18

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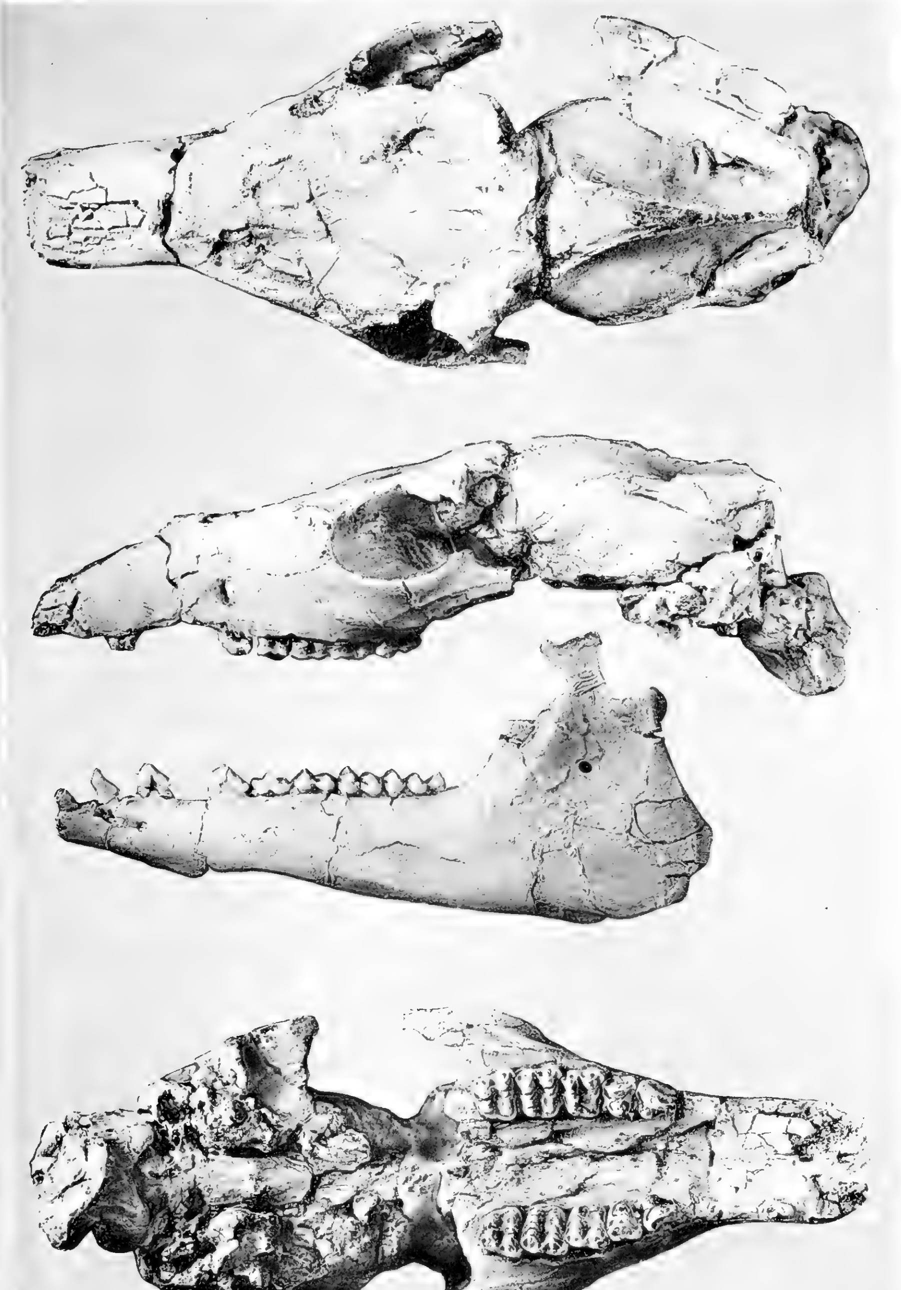
Fig. 2. *Leptoreodon marshi* Wortman: Left ramus of mandible (U.S.N.M. No. 20397), occlusal and lateral views. Approximately three times natural size. White River pocket, Uinta Basin, Utah.



MYTONOMERYX FROM THE UINTA UPPER EOCENE

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HOMACODONTS FROM THE UINTA UPPER EOCENE

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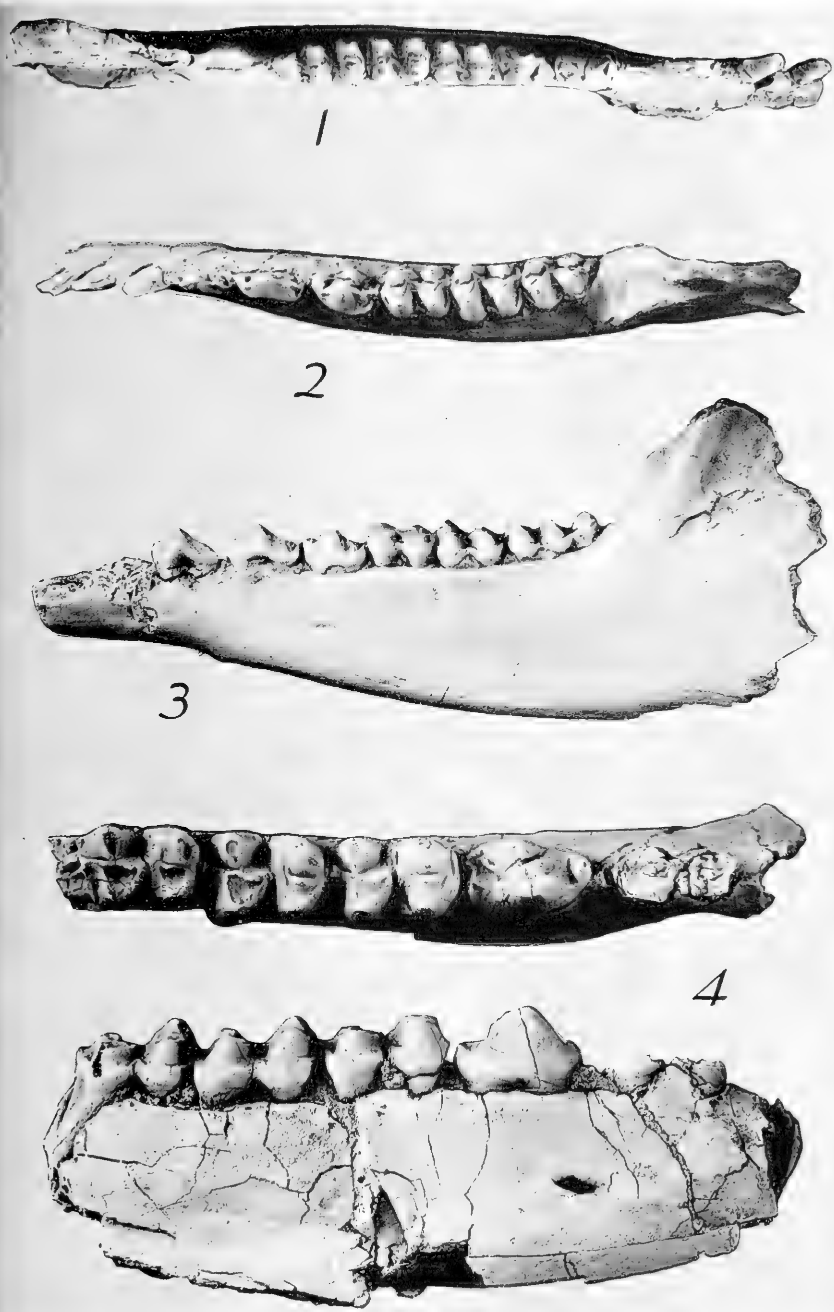

HOMACODONTS FROM THE UINTA UPPER EOCENE

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PROTOREODON FROM THE UINTA UPPER EOCENE

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PROTOREODON FROM THE UINTA UPPER EOCENE

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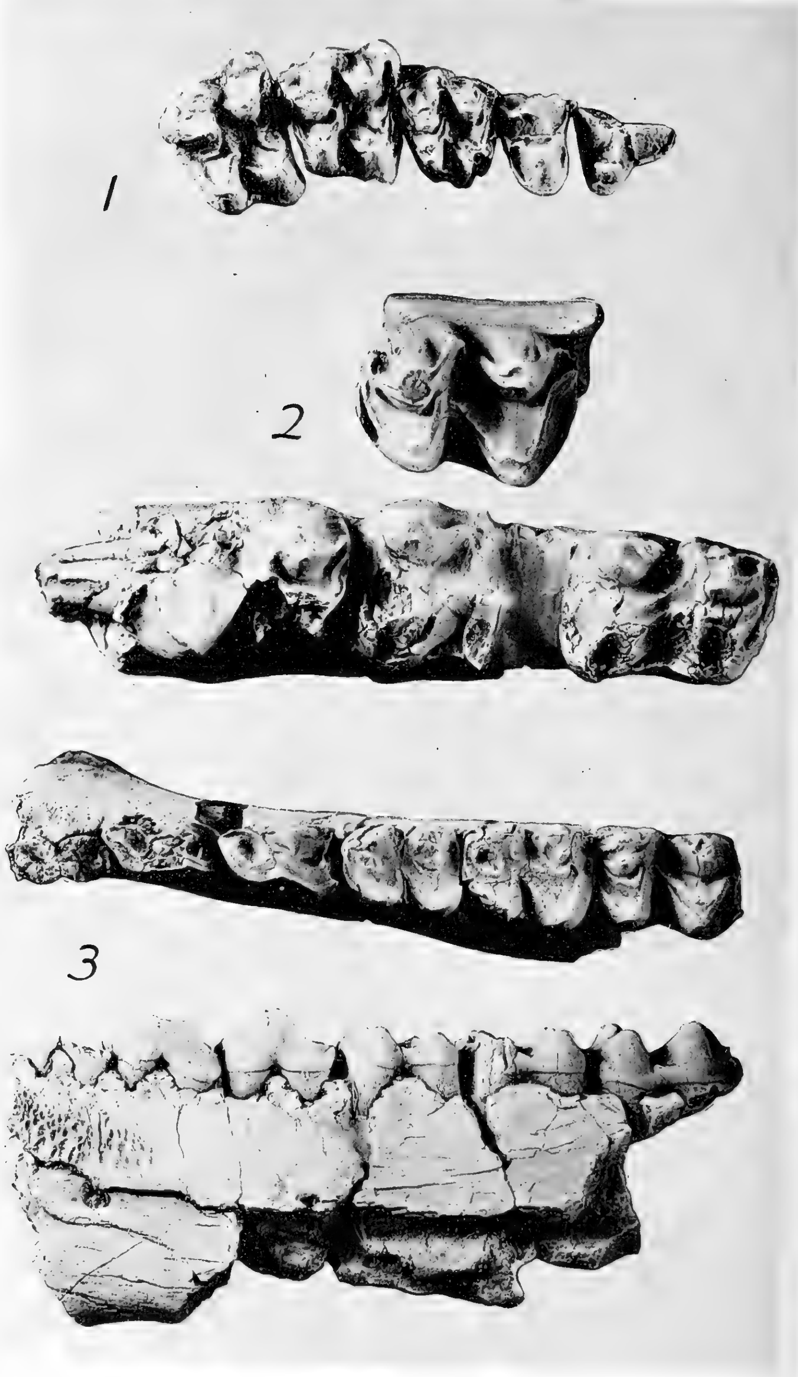

PROTOREODON FROM THE UINTA UPPER EOCENE

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PROTOREODON FROM THE UINTA UPPER EOCENE

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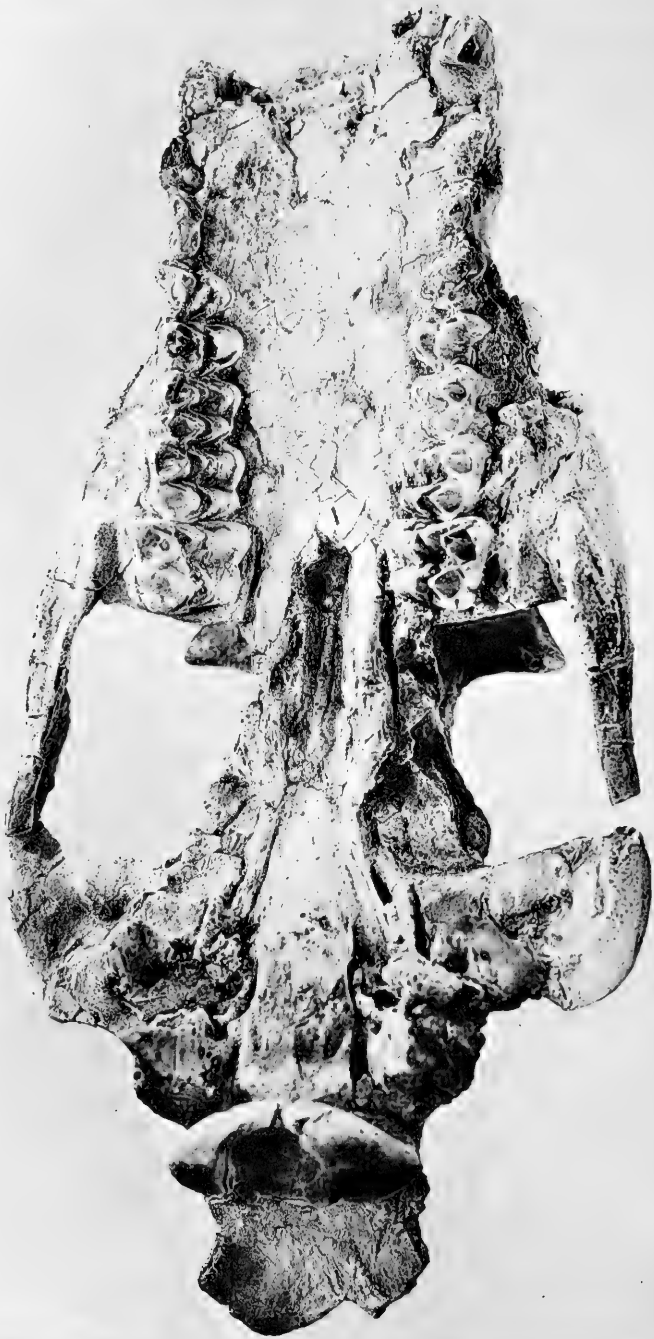

DIPLOBUNOPS FROM THE UINTA UPPER EOCENE

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

DIPLOBUNOPS FROM THE UINTA UPPER EOCENE

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

Diplobunops from the Badwater Upper Eocene

DIPLOBUNOPS FROM THE BADWATER UPPER EOCENE

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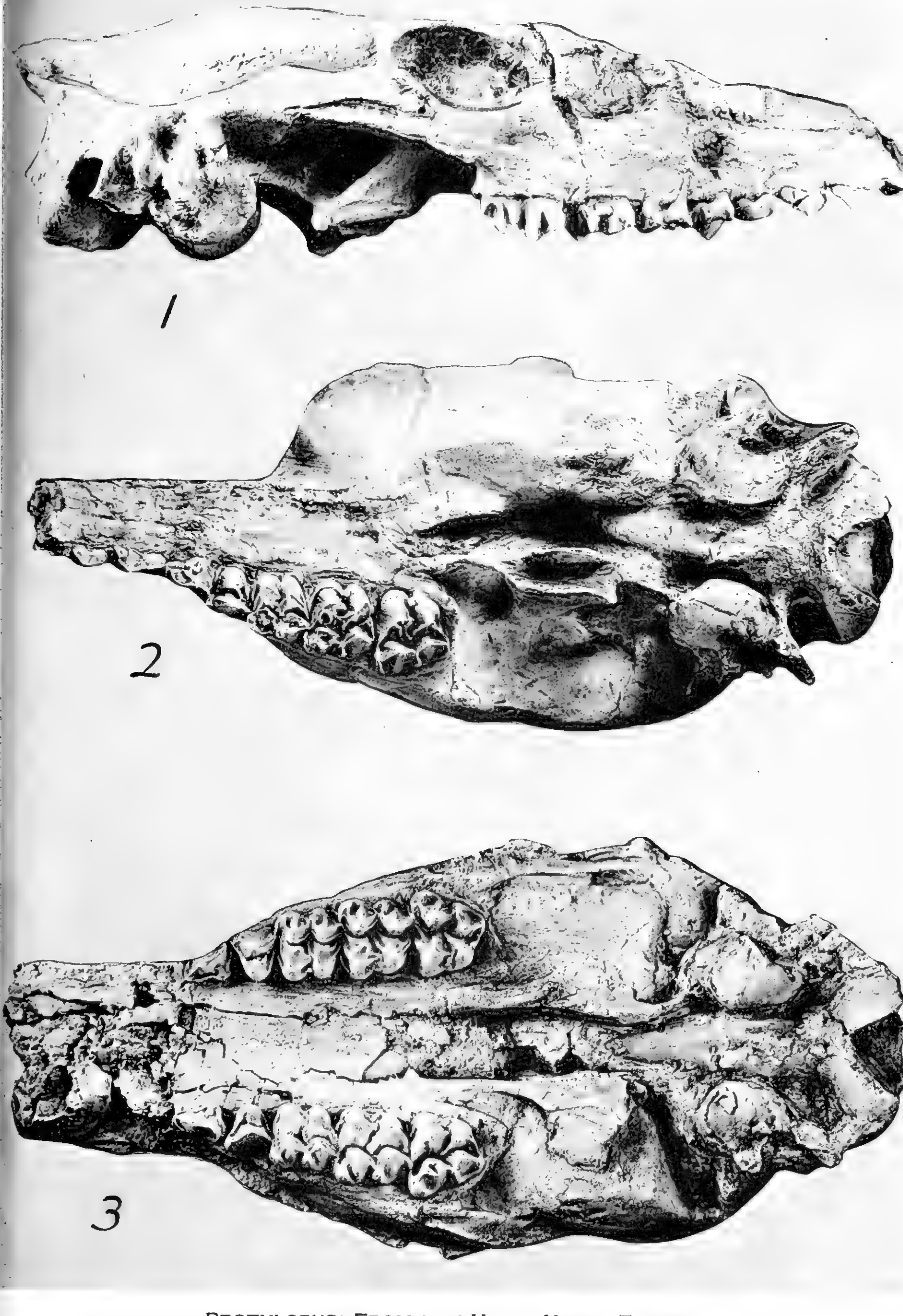
DIPLOBUNOPS FROM THE BADWATER UPPER EOCENE



PROTYLOPUS? FROM THE UINTA UPPER EOCENE

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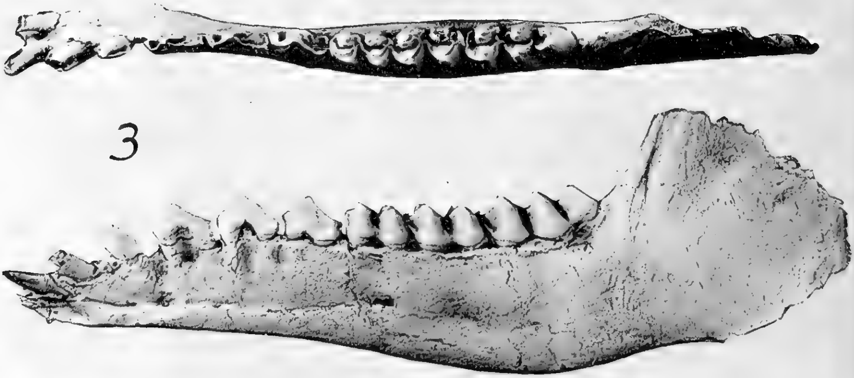

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PROTYLOPUS? FROM THE UINTA UPPER EOCENE

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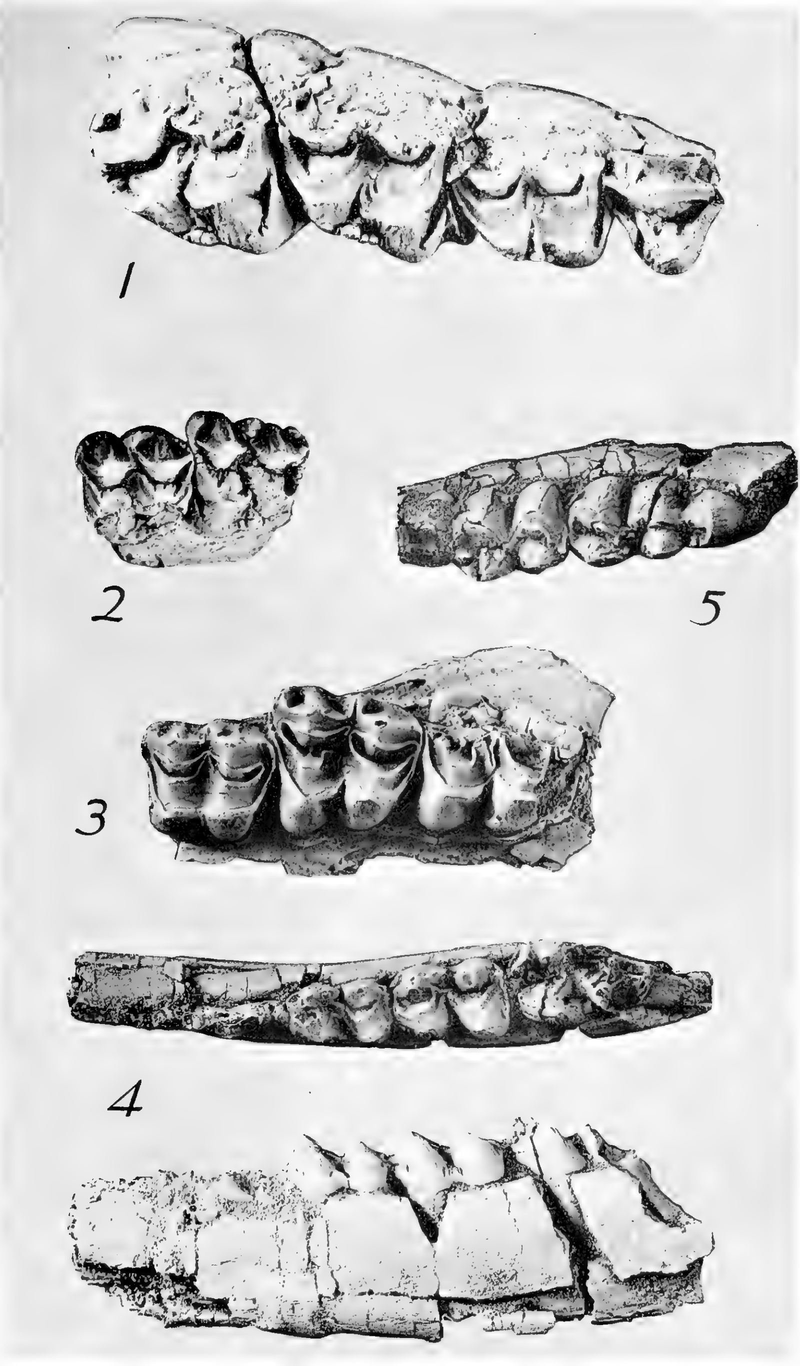

OROMERYX AND POËBRODON FROM THE UINTA UPPER EOCENE

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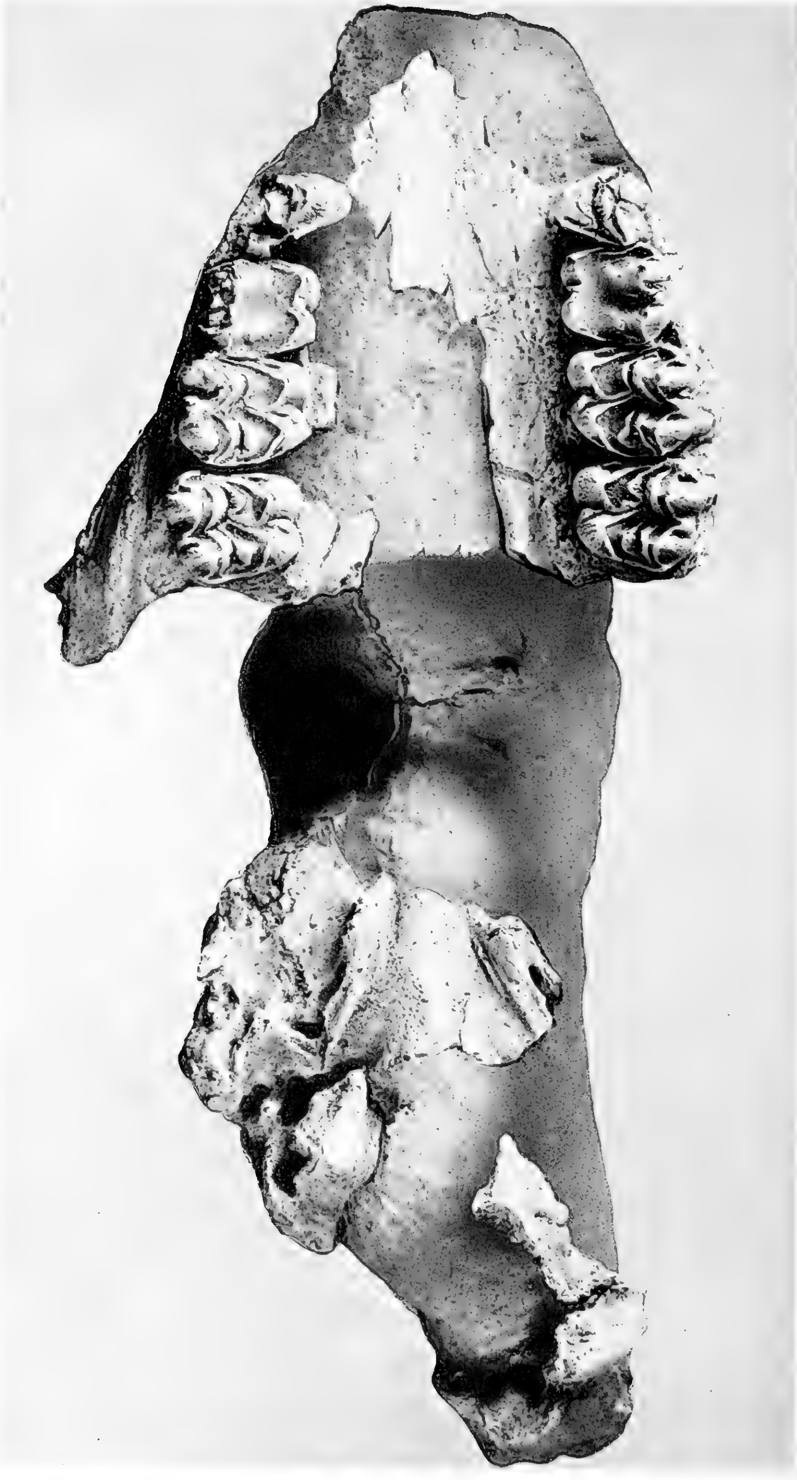

MALAQUIFERUS FROM THE UPPER EOCENE OF THE WIND RIVER BASIN

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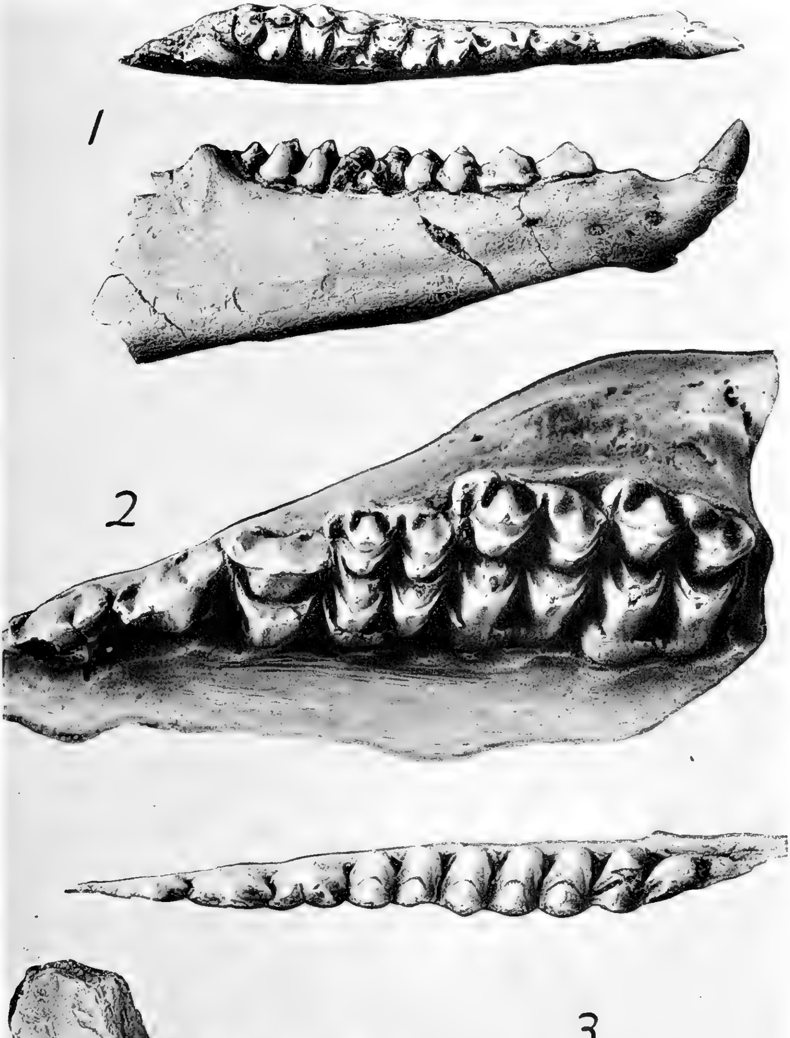

LEPTOTRAGULUS FROM THE UINTA UPPER EOCENE

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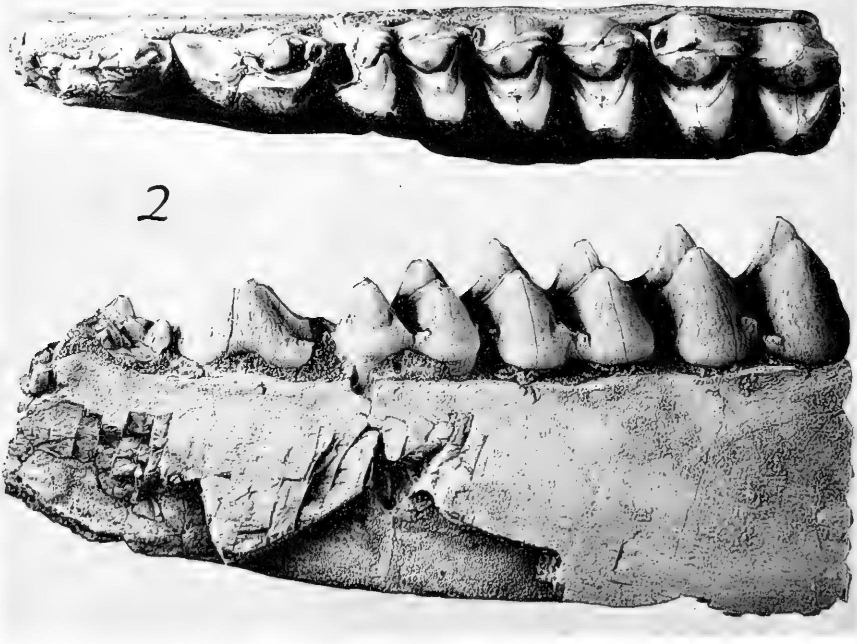

2

LEPTOTRAGULUS AND LEPTOREODON FROM THE UINTA UPPER EOCENE

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

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DISTRIBUTION AND ECOLOGY OF THE MARINE INVERTEBRATES OF POINT BARROW, ALASKA

(With 8 Plates)

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CONTENTS

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(With 8 Plates)

INTRODUCTION

ARCTIC EXPLORATIONS[1]

Our knowledge of the fauna of Arctic waters is fairly complete for some areas, scanty for others, and totally lacking for still others. The European Arctic and the eastern Canadian Arctic have been more thoroughly investigated than have the western Canadian Arctic and the Alaskan Arctic. The following partial recapitulation of expeditions and investigations gives some idea of the European research on the biology of the Arctic Ocean.

As early as 1587 the British, under John Davis, explored around west Greenland as far north as latitude 72°12′, and in the next two centuries the Dutch, under Willem Barents and Henry Hudson, and the British, under C. J. Phipps, explored around Spitsbergen to latitude 80°48′ N. From 1879 to 1882 the British continued explorations around Spitsbergen, Jan Mayen, and Franz Joseph Land. Such expeditions as the above and that of the *Maud* (see below) were more exploratory and oceanographical than biological in nature. The Second German Northpolar Expedition, under Capt. Karl Koldewey (1869-70), explored around east Greenland. Dredging excursions to Iceland were carried out under Verkruzen about 1872. The Danish *Ingolf* Expedition of 1879 also explored around east Greenland. Den Norske Nordhavsexpeditionen of 1876-78 worked in the European Arctic. The west coast of Greenland was explored in 1892. The

[1] The present study was made possible through contracts of the California Institute of Technology (summer, 1948) and The Johns Hopkins University (June 1949-August 1950) with the Office of Naval Research (Contract and Task Order No. N6-ONR 243-16; Project No. NR 162 911).

Second Norwegian Arctic Expedition in the *Fram* (1898-1902) went from northern Norway through the Barents Sea, the Kara Sea (between Novaya Zemlya and Russia), the Laptev Sea, and to the east around west Spitsbergen. Between 1879 and 1900 there were various Swedish expeditions to east Greenland and other regions. The Plankton Expedition of 1903 included the waters of Iceland. The Russians sent an expedition to Spitsbergen, and the Bremer Expedition of 1889 also explored around east Spitsbergen, the Kola Fjord, and the southwest parts of the Barents Sea. The Danish expeditions of 1906-08 did work along the northeast coast of Greenland. The Norwegian North Polar Expedition in the *Maud* from 1918 to 1925 wintered three times on the Siberian coast on their way to Alaska, spent two years drifting from Wrangell Island to the north of the New Siberian Islands, wintered at the Bear Islands at the mouth of the Kolima, and then went to Nome. The Godthaab Expedition did work along the west coast of Greenland in 1928, and there were Danish investigations in the Faroes between 1924 and 1927. Various Danish expeditions worked rather intensively along the east coast of Greenland from 1929 to 1933, in some instances leaving investigators over winter.

Nothing comparable to the work done along the coast of Greenland, Iceland, and the Faroes has been done in the American Arctic. The fauna of northeastern Arctic Canada is better known than that of Arctic Alaska or the western Canadian Arctic. Some work has been done in the American Archipelago, and at present the Canadians are carrying on investigations. Recently Dr. M. J. Dunbar has made excellent contributions from Ungava Bay and other waters in that region.

Lt. Ernest Belcher, on the voyage of the *Beechey* in 1825-28, did some collecting as far north as Icy Cape, but the majority of his work was south of Bering Strait. The *Vega* expedition did some work in the Kara Sea, Laptev Sea, the East Siberian Sea, the Chukchi Sea, Bering Strait, and Bering Sea. Lt. P. H. Ray and his party were stationed at Point Barrow and vicinity in 1881-83 (the International Polar Expedition to Point Barrow), but their work was largely meteorological and they lacked proper facilities for collecting. This is borne out by the fact that they collected only 180 species of animals. The Canadian Arctic Expedition of 1913-18 did very little work north of western Canada and Alaska. Of the various voyages and expeditions that visited Arctic Alaskan waters (such as the *Resolution* and *Discovery* under James Cook, the *Seniavine* under Lütke, and the *Vincennes* under Rogers) probably the most important from the

standpoint of collections of invertebrates were those of the *Yukon* (U. S. Coast and Geodetic Survey schooner) under the leadership of Dall (1880) and the *Corwin* under Captain Healy (1884 and 1885).

These investigations were much less intensive than those of the Danes about Greenland; they were too spotty, and the animals collected were sometimes so poorly preserved as to be of little value. Such expeditions can give only a general picture of the fauna, and the research is usually more oceanographical than biological or ecological in character.

Only through continued intensive work in a small area can anywhere near an accurate picture of the fauna of a region be obtained. The present work was undertaken for the purpose of obtaining as much information as possible on the fauna of Point Barrow. As this is about midway between the areas that have been investigated to the east and to the west, it was a strategic locality for the study of circumpolar distribution of species, and the extension of our knowledge of the Arctic marine animal population and its environment far to the westward.

The work was carried out through the facilities of the Arctic Research Laboratory, which was maintained by the Office of Naval Research under contract with the Institute for Cooperative Research, a branch of the Johns Hopkins University.

LOCATION, GENERAL SURROUNDINGS, AND FACILITIES

The Arctic Research Laboratory is located within the base camp maintained by the Arctic Contractors (Arcon), who were under contract with the U. S. Navy to explore some 37,000 square miles of oil reserve. The personnel of the camp, both Navy and civilian, were very cooperative, and much of what was accomplished could not have been done without their aid.

The base is located 6 miles southwest of Point Barrow and 4.5 miles northeast of the village of Barrow at approximately latitude 71°20′ N. and longitude 156°41′ W., 4°50′ above the Arctic Circle, and 1,325 miles from the North Pole. It is on the beach at the edge of a great tundra plain, and no elevations over 10 feet are visible in any direction. The ocean there has no tide. The weather is stormy, but there is no snow for perhaps three months, though there may be flurries in July and August. There are about two months of perpetual daylight in summer and about two of perpetual darkness in winter, except for twilight at noon. There was plane service three days a week be-

tween the base and Fairbanks, and an operation called BAREX brought in supplies about the first of August of each year.

In 1948 the Arctic Research Laboratory consisted of a 2-story quonset building 40 by 100 feet (pl. 1, Bldg. No. 250) and a smaller 1-story quonset 20 by 60 feet (Bldg. No. 270). During 1950, while the writer was scientific director, another 40-by-100-foot quonset

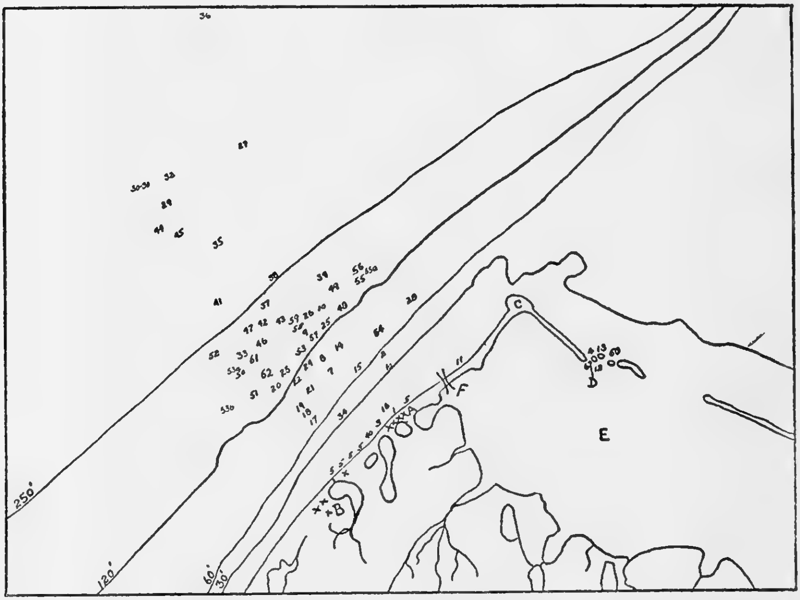


FIG. 1.—Map of Point Barrow. (Adapted from U.S.C.G.S. Map 9445.) *A*, Arctic Contractor's base. *B*, Barrow Village. *C*, Point Barrow. *D*, Eluitkak Pass. *E*, Elson Lagoon. *F*, Location of channel opened by Arcon each year. Nos. 1-62, Dredging stations.

(pl. 1, Bldg. No. 251) was added and Building No. 270 was turned back to the Arctic Contractors. The new 2-story building was connected to the older one (No. 250) by a 20-by-90-foot quonset (pl. 1), which served as a machine shop and storeroom. The upper story of No. 251 was divided into sleeping rooms, and the lower floor was made into laboratories. The upper story of No. 250 served as a library, chemistry storeroom, and offices for the scientific director, plant manager, and secretary. The laboratory contains 18 research rooms and has facilities for about 30 workers (pl. 2, fig. 1).

PERSONNEL

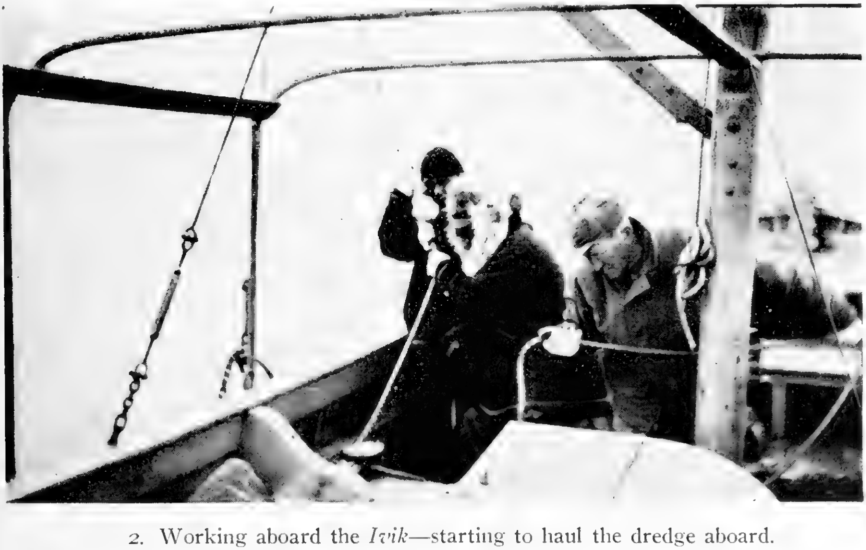
The group working on this project included the writer as principal investigator; Mrs. MacGinitie, research associate at Point Barrow;

Arctic Research Laboratory, north exposure. Building No. 250 on left, No. 251 on right, with connecting one-story shop and storehouse.

1. Personnel at Arctic Research Laboratory, summer, 1950.

2. Ice-cutting device. Jacob Stalker on left, John Huff on right.

1. The *Ivik,* 36-foot dredging boat, summer, 1949, before the cabin was added.



2. Working aboard the *Ivik*—starting to haul the dredge aboard.

1. Dredge haul on deck of *Ivik*, ready for field sorting.

2. Snow house over sampling hole in shore ice near base.

Dr. Marian H. Pettibone, research associate at the U. S. National Museum; Howard Feder, research assistant at Point Barrow from July 1949 until June 1950; and Gail Grodhaus, who came in July 1950 and stayed through September.

Mrs. MacGinitie and I spent three months at the Point during 1948, from July 10 to October 10, and a second period from June 30, 1949, to August 14, 1950. The contract for the first period was made by the California Institute of Technology with the Office of Naval Research, that of the second by the Johns Hopkins University. During the second period the writer also served as Scientific Director of the Laboratory.

EQUIPMENT

The Navy and the Office of Naval Research were generous regarding equipment. For two months during the summer of 1948 an Eskimo boat, with two boatmen, was rented, but in 1949 a 36-foot boat named the *Ivik,* meaning "walrus" (pl. 3, fig. 1), was furnished by the Navy and sent to the base by BAREX. This was equipped with a 25-hp. diesel engine, which was later changed to a gasoline engine. It was a seaworthy craft and the best imaginable for the purpose. Before it was taken to Point Barrow it was sent to the Kerckhoff Marine Laboratory of the California Institute of Technology, where it was equipped with winch, mast, boom, and other accessories, including a canvas hood. In the spring of 1950 the latter was replaced by a suitable cabin. In addition to cabin space and space in the stern, there is an open working space of approximately 10 by 14 feet (pl. 4, fig. 1). A 5-hp. outboard motor and a skiff were carried for safety in the event of breakdown or jamming in ice.

A meter wheel, dredges, towing nets, and other necessary gear, were part of the equipment. A set of Kohl hydrometers was purchased for use in determining the salinity of the water. One binocular microscope was furnished in 1948 and another in 1949. All necessary glassware, specimen bottles, and other laboratory equipment were procured.

PHYSICAL AND CHEMICAL FEATURES

CLIMATE AND VEGETATION

Some of the statistical information about weather contained in this discussion was taken from reports of the U. S. Weather Bureau offices at Point Barrow and Fairbanks.

The most interesting and perhaps the least known feature of the

weather at Point Barrow is its aridity. The average annual precipitation is only about 4 inches. There is no building-up of the ice reserve on the northern slope of the Brooks Range, which is 250 miles to the south of Point Barrow. Therefore, one can estimate that, even after eliminating loss by evaporation, approximately 10 million acre-feet of fresh water empty annually into the ocean. At least four-fifths of this flows into the ocean east of Point Barrow, where currents carry it mainly westward to the Point and sometimes beyond.

Although the relative humidity is usually high, the temperature is so low that little moisture is held. It is cloudy 50 to 60 percent of the time. There are more clear days in winter just before, during, and just after those months when the sun is below the horizon. Any day of the year may bring a snow flurry, though during June, July, August, and September the precipitation is usually in the form of a drizzly rain. As one goes by plane between Point Barrow and the Brooks Range (250 miles) during the summer, one is almost certain somewhere to pass over a white strip where there has been a snow squall. Such strips are about 10 miles wide. In the afternoon of July 23, 1948, 3 inches of snow fell at Point Barrow.

February 1950 was the coldest month on record, with an average temperature of $-23.8°$ F. The lowest temperature on record there is $-56°$ F. The highest in 1946 was on July 10 with 73° F. and the lowest the same year was $-37°$ F., which was recorded on three different days—February 25, March 10, and December 29. The highest temperature in 1949 was 63° F. on August 11, and the lowest that year was $-51°$ F. on February 16. The highest temperature that Ray (1885) recorded during his stay near Point Barrow was 60.5° F., and the lowest was $-52.6°$ F.

Much of the dredging I did was carried on in fog of such density that visibility was limited to one-fourth mile or less. An interesting phenomenon was the presence of a bright spot in the fog on the side opposite the sun. By knowing the time of day, the proper direction of the boat could be determined by this lighter area, which was a great help in navigation since compasses were unreliable because of the nearness to the magnetic pole and the consequent high angle of the magnetic dip, or the magnetic lines of force. I learned to depend for navigation more on my own senses and those of the Eskimo boatmen (particularly the latter) than on a compass.

Although many days are relatively calm, winds are changeable and at times come up quickly to gale force. The average velocity is 12 miles an hour, but winds of 40 miles are not uncommon. While the boat and its crew were returning from one dredging trip about

10 miles offshore, a blow of such violence came up that it was necessary to go to shore 6 miles below the landing and work slowly alongshore to the base, where the boat could be pulled out. Had the boat been forced directly to the landing it would have been swamped. That day the "No. 1 Boatman" (Max Adams) said, "I got a itta bit tsick."

The vegetation consists of lichens, mosses, grasses, sedges, and flowering plants. There are two species of low willows that grow in the Arctic tundra. The largest of these is a branching, decumbent plant that does not project more than 2 inches above ground and seldom covers an area of more than 3 feet in diameter. One of these willows may be found almost at land's end at the Point. Farther inland along streams another species of willow that may attain a height of 10 feet is abundant.

Plants in the Arctic grow slowly. Two different Government men, interested in reindeer propagation, told the writer that overgrazed land requires 50 years in which to regain fully its plant life.

The contribution of terrestrial plants to the economy of the sea is brought about mainly through shore erosion, though some plants are brought to the ocean by rivers. This relationship is further explained under "Currents" and "Food."

No account of the plants of the tundra would be complete without some mention of the summer flowers. Those who think of the Arctic waste as a dreary, uninviting area should visit the region in August and see the profusion of flowers and birds. All flowers are short-stemmed and small, but most of them are beautiful. A delightful memory is of a field of poppies on the bluff alongshore several miles southwest of Barrow Village, and the great fields of golden sedges of the tundra are a never-to-be-forgotten sight.

GEOLOGY

To understand the sediments of the ocean shore and bottom at Point Barrow and vicinity it is necessary to go a considerable distance to determine the source. Much of the shore and bottom materials has come from the Brooks Range to the south. These mountains, 7,000 to 8,000 feet high, extend east and west across northern Alaska (fig. 2) a distance of 600 miles. Some shore and bottom materials are ice-borne from great distances. More will be said about this under "Currents."

Geologically the north slope, i.e., that part of Alaska from the Brooks Range to the Arctic Ocean, may be divided into three general regions: (1) The mountains of the northern slopes are sedimentary formations. (The whole range, though sedimentary, shows granite

intrusions, indicating an igneous core.) Shale and limestone predominate. (2) The mountain slopes verge into an undulating plain which includes most of the drainage basin of the Colville River (25,000 square miles). This second region is sharply set off from (3) the great wet tundra plains by an old beach escarpment which is 50 to 300 feet above the lake and pond area to the north—some 25,000 square miles that is more water than land. At the foot of this escarpment the elevation is about 400 feet above sea level. This gives a fall of 400 feet in about 100 miles to the coast at Barrow. The

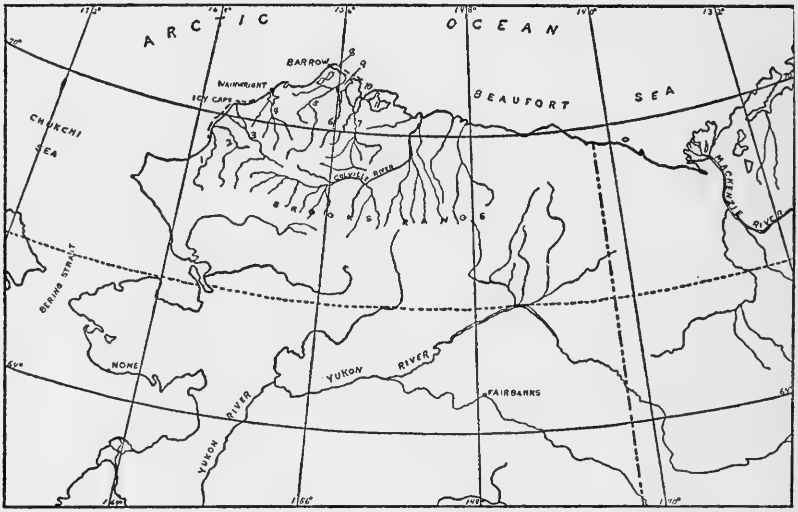


FIG. 2.—Map of northern Alaska. 1, Kukpoivruk River. 2, Kokolek River. 3, Utokok River. 4, Kuk River. 5, Meade River. 6, Topagoruk River. 7, Ikpikpuk River. 8, Elson Lagoon. 9, Admiralty Bay and Dease Inlet. 10, Smith Bay. 11, Teshekpuk Lake.

drainage surface thaws to a depth of 12 to 18 inches during summer, which is the only time of year when any movement of water occurs over the tundra. Throughout this plain the ground is frozen to a depth of nearly 1,000 feet (permafrost). All but the largest rivers freeze solidly in winter. Lakes are very numerous and in general are oriented north and south.

Many rivers in this third region flow northward to the Arctic Ocean (fig. 2) ; three large ones, the Meade, Topagoruk, and Chip, empty into Admiralty Bay, which in turn becomes Dease Inlet and Elson Lagoon. To the southwest is the Kuk River, which enters the ocean at Wainwright. Beyond Icy Cape are the mouths of three rivers, the Utokok, Kokolek, and Kukpoivruk. To the east of Elson

Lagoon is Smith Bay, into which flows the Ikpikpuk River. Teshekpuk Lake, the largest lake on the northern slope, empties into the same bay through a channel, the mouth of which joins the delta of the Ikpikpuk. These rivers are important to the marine life off Point Barrow for they affect the salinity of the water and carry to the ocean organic material that supplies some of the detritus on the bottom offshore.

As has been mentioned under "Climate," the average annual rainfall of the northern slope is only about 4 inches, so the runoff is not great. Because of the relatively slight variation in elevation, these rivers meander amazingly and the currents are slow. Occasionally one lake may break through into another, and the resulting flow of water thaws the permafrost and sometimes cuts a channel several feet deep.

The discharge from Elson Lagoon has more effect on the ocean water near Point Barrow than that from any other source. There are several reasons for this: (1) The fresh water from the rivers flowing into Elson Lagoon through Admiralty Bay and Dease Inlet is of considerable volume. (2) The lagoon is large and quite shallow. Reference to U. S. Coast and Geodetic Survey map 9495 shows that Elson Lagoon, Dease Inlet, and Admiralty Bay together form a body of water 90 square miles in area, and nowhere is the depth more than 12 feet. The bottom is a blue mud, which is stirred up by wind waves, and carried in large quantities into the sea, sometimes coloring it for miles alongshore and offshore. (3) The body of water under discussion has a shoreline (not including the chain of islands separating the lagoon from the ocean) of about 100 miles which is eroding very rapidly in summer. During the fall of 1949 not only was the ocean muddy but also great quantities of tundra (lichen masses and grasses, including roots) were floating in it. This large amount of organic matter, derived mainly from the eroding shoreline of the lagoon and from the rivers, furnishes the detritus of the ocean floor to a distance of 25 miles from shore, which was as far out as dredging was carried on. It is my opinion that such material from the shores of the Arctic Ocean and contributary rivers supplies detritus throughout the entire Arctic Basin.

Along the beach at Point Barrow and for hundreds of miles east and west, erosion is proceeding at a rapid rate. Point Barrow proper has receded 28 feet in four years—a rate of 7 feet a year. At one place in Elson Lagoon the shore has eroded inland 115 feet in four years. These figures were supplied by Dr. G. R. MacCarthy, of the U. S. Geological Survey, who obtained them by measuring the tri-

angulation targets of the U. S. Coast and Geodetic Survey set in 1945 with reference to the beach line.

The beach is of gravel, composed of approximately 90 percent chert with an admixture of igneous and sedimentary pebbles of white, red, and gray sandstone, granite, and basalt, with a very small percentage of limestone, derived mainly from the Brooks Range. This gravel extends out to an irregular line where the water is 10 to 20 feet deep and is there replaced by a silty marine clay of extremely fine grain. This clay is spoken of as blue mud and extends inland under the tundra at a depth averaging 40 feet. It is so sticky that an hour or more is required to wash it out of a dredge. Where erosion has removed the clay from under the tundra, the dredge often brings up chunks of tundra from 50 to 75 yards from shore.

Beyond the blue-mud zone is the rubble zone, consisting of pebbles ranging from one-eighth inch or less in diameter to boulders that may weigh tons. This rubble is ice-borne and is rather spotty. Sometimes the dredge brings up gravel, but at others it jumps and jerks, showing the presence of large boulders. Rocks 20 pounds in weight are sometimes brought up. The composition of the rocks is approximately the same as that of the beach gravel. As one goes farther from shore the boulder-strewn bottom is replaced by finer gravel and shell beds, mostly *Hiatella* (=*Saxicava*). Inland there are, in the coastal plain, many old beach lines, showing that the area has been uplifted and depressed in relation to the sea, and tundra is sometimes encountered many feet under the surface.

ICE

Ice exerts a great influence on the shore and bottom fauna off Point Barrow. N. A. Transehe (1928) places the ice of the Arctic Ocean in three classes: Fast ice along shore, pack ice (more or less freely moving ice), and the Arctic pack. The first is 5 percent of the whole, the second about 25 percent, and the Arctic pack itself constitutes 70 percent of the Arctic Ocean ice.

None of this ice is stable. Papanin (1939) showed that the Arctic pack moved in the direction of the Atlantic off Greenland at the rate of 1,000 miles in nine months. In this pack, leads open and close or freeze over and are piled into new ridges. There is, therefore, no indication that any part of the Arctic ice is very old. Most of the pack flowing out past Greenland is probably not more than four years old, and much of it only two or three. If, as seems to be indicated, there is a gyral in the Beaufort Sea, it is possible that ice may last several

years there, and some at Point Barrow may be more than four years old. There is good evidence for considering the Arctic pack as a great moving field, the direction of which is from northeast Siberia to the east of Greenland.

One factor that has not been given the attention it deserves is the rate of melting. The writer believes that if it were not for the piling up of the ice during storms and its subsequent incorporation in the Arctic pack there would be little ice in the Arctic Ocean by September of each year. Probably nowhere in the Arctic does the water freeze to a thickness of more than 6 feet (certainly not more than 7 feet) in any one winter. The winter of 1949-50 at Point Barrow was very cold. The average daily temperature for the month of February was the coldest on record, $-23.8°$ F., yet the ocean ice alongshore was only 68 inches thick. The thousands of lakes and ponds freeze to a depth of about 7 feet and this ice melts entirely in summer. In cruising among the floebergs (pl. 6, fig. 2) one often sees floes that are only 1 or 2 feet thick. These are from leads that froze over without subsequent piling up of the ice, and such floes entirely disappear by September. However, there is no way of knowing how thick they were originally.

Ice can form deeper in regions where fresh water runs under the ocean ice—for example, in and near Elson Lagoon it may be as much as a foot thicker than nearby shore ice. Since fresh water floats on salt water, when it is carried out under the ice sheet the lack of wind disturbance allows it to spread out under the ocean ice for a considerable distance. However, fresh water freezes at a higher temperature than ocean water and, since the fresh water is between the cold ice above and the below-zero water beneath, it does not travel more than a few miles alongshore before freezing. Hence some of the alongshore ice near Elson Lagoon thickens more rapidly than that offshore.

A discussion of how the ice forms offshore, beginning in October and continuing until the ice goes out the following July, may be of interest. To begin with, ocean ice is different from fresh-water ice. A slush forms on the surface of the ocean alongshore and gradually creeps oceanward. When this slush becomes about 4 inches thick it begins to solidify on top and a great sheet of ice is formed for perhaps one-fourth to one-half mile seaward. Some time later an onshore wind, with or without swells in the ocean water, breaks up this sheet, and chunks of ice, large and small, are slid over the shoreward ice until they are piled up into a ridge. (In 1949 the first ice alongshore broke up and was carried in to the beach itself, forming a ridge

15 feet high.) New sheets form and the process is repeated until the ocean is covered with ridges of rough ice (pl. 5, fig. 2) to a considerable distance at sea. This distance varies with seasons but may be 6 or 8 miles. However, the outer few miles of ice over water more than 100 feet deep are never stable. Storms open leads and these close again. Leads remain open for varying lengths of time, but a layer of ice several inches thick usually forms within a few days, and if there are no onshore winds of sufficient force to pile it up, it continues freezing to a greater thickness. Eventually the pressure of the outer ice breaks it up and piles it up several layers thick (pl. 5, figs. 1, 2). Leads may be from a few feet to several miles wide, and from a few hundred feet to several miles long. The ice ridges may be 100 feet or more across, 20 feet or more in height, and a few hundred feet to several miles in length. Thus the shore ice presents a series of ridges of varying length, breadth, and height, and between these may be areas of varying size that are relatively smooth and level, where the vagaries of storms and currents have permitted the ice to form without being disturbed.

Nearly every fall the floating, drifting ice offshore, which is old ice sometimes almost equaling icebergs in size, comes shoreward and grounds. Since ice is about seven-eighths under water, this ice grounds offshore where the water is 60 to more than 100 feet deep and forms what is spoken of as "the big pressure ridge." Owing to the force of ice behind it, it may pile up as high as 30 feet or more.

The following are the days in the years 1941 to 1947, inclusive, on which the ice permanently formed an unopen ridge offshore:

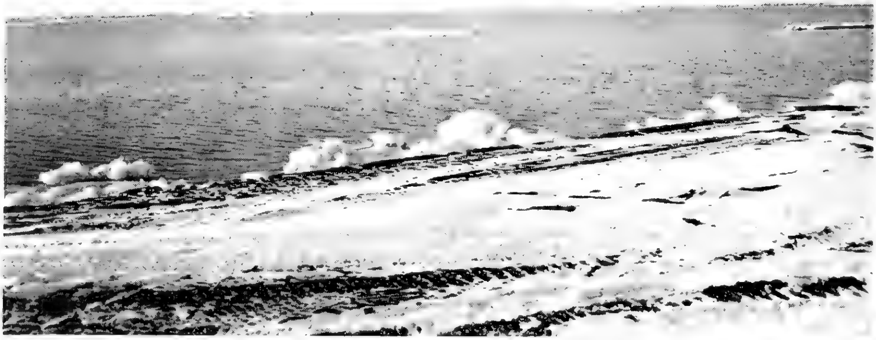
1941	November 1	1945	October 20
1942	November 10	1946	November 9
1943	October 15	1947	October 13
1944	October 18		

In 1948 the ice broke up on July 23, and on only one day throughout the remainder of the summer was the pack ice not visible from shore and then it could be seen from any elevation of 20 feet, or a height above ground of 8 or 9 feet. A useful equation for the curvature of the earth, and, therefore, the distance objects can be seen at sea, is $\sqrt{h}+\frac{1}{3}\sqrt{h}$. The shore at Point Barrow base is 11 feet above sea level, so the horizon, to a man whose eyes are 5 feet above ground, is $\sqrt{16}+\frac{1}{3}\sqrt{16}$ or $5\frac{1}{3}$ miles. If the ice itself is 10 feet high, then it can be seen from shore when it is about 9 or 10 miles out.

Three times during the summer of 1948 the edge of the pack ice approached shore, and many small ice floes were grounded. One

1. Ice over Arctic Ocean. The dark strip along the horizon is caused by vapor condensing over a lead and is referred to as "smoke."

2. Another view of an ice field on the Arctic Ocean, also showing "smoke" over a lead in the distance.



1. Arctic Ocean. Ice offshore, summer, 1949.

2. Arctic Ocean. Floeberg from pressure ridge, summer, 1948.

1. Iceberg grounded offshore near Point Barrow. Note striations showing glacial origin. This iceberg undoubtedly came from the American Archipelago.

2. A crevasse in the iceberg shown in figure 1.

1. Ice pushed ashore by storms, winter, 1950.

2. Traveling by dog team over the ice on the Arctic Ocean.

could often jump from shore onto a floe. Pack ice is a loose aggregation of floes of all shapes and sizes often forming streaks of varying width with open leads between. However, these leads are never free from small pieces of ice, and the boat coxswain must be continually alert to avoid collisions. Among the writer's most pleasant memories are days in the summer of 1948, cruising about among the ice floes looking for leads of sufficient extent to allow dredging. Those days were made all the more enjoyable by the companionship of the two Eskimo boatmen Max Adams and Olaf Avenosook.

In the summer of 1949 the ice went out during the night of July 19, was in sight the following day, and then never came near shore again that summer. No ice floes of any kind were visible until July 29, when a few small floes grounded ashore and remained for a day or two. After that no ice at all was seen. At different times aviators reported the pack ice at distances 60 to 140 miles offshore. Since the big ice did not come in during the fall, no large pressure ridge formed. By inquiry from elderly Eskimos who had lived at Point Barrow all their lives, it was ascertained that this phenomenon has happened perhaps five times in the past 50 years, or on an average of perhaps once in 10 years.

Icebergs are formed by the breaking off of high pieces of glaciers extending into the sea. The nearest glaciers to Point Barrow are to the east in the Canadian Archipelago and in Greenland. In the summer of 1948 a large iceberg (pl. 7, figs. 1, 2) grounded off Point Barrow. It was at least 25 feet high and was stratified, looking like no other ice ordinarily seen at Point Barrow. It had fairly straight sides and was grounded in about 200 feet of water. The dimensions were about 70 by 100 feet and the top was fairly flat. This berg was viewed from a PBY by Commander Paton of the U. S. Coast and Geodetic Survey, Dr. Dobrin of the Naval Ordnance Laboratory, the two pilots, a newspaper correspondent, and the writer. The pilot flew alongside the iceberg and said his altimeter showed it to be 25 to 30 feet high.

During the following winter two of these large icebergs grounded about 25 miles northeast of Point Barrow base. Because of the strong prevailing northeast current flowing past the Point and meeting the northwest current out of the Beaufort Sea, the water is shallow for miles northeast of Point Barrow, which accounts for the bergs' grounding so far from shore. These icebergs undoubtedly came out of the Beaufort Sea with the northwest current mentioned above. If this supposition is true, it brings up problems of great interest. How

did they get into the Beaufort Sea? Where did they originate? How long were they on the way to Point Barrow?

Anywhere inshore from the big pressure ridge smaller floes ground and freeze into the layer forming from shore to ridge. This occurs only in those years in which the big pressure ridge forms, which, as has been said, is at least nine out of ten. These big pieces of ice ground at different depths and crush any animals living on the surface of the ocean bottom.

If there were no folding of the ice into ridges as it freezes, it would reach a yearly average thickness of about 6 feet. From the big pressure ridge toward shore there is usually a great deal of unbroken ice. For a distance of 3 to 5 miles offshore, animals are continuously covered by an ice sheet, except for occasional leads, from about November 1 to July 1 each year. From shore to a depth of over 100 feet offshore the bottom is rubbed and gouged by ice.

The underside of the ice is as rough as, or rougher than, the surface and, in addition, during most of the time from November to April, is covered underneath by 3 or 4 inches of slush as the water continues to freeze. When freezing stops, the slush disappears, and from May to October little or none exists.

Ice serves as a refuge or resting place for many animals, particularly amphipods, worms, and the Arctic cod. The floating ice is as important in this respect as that which is frozen solidly together. No animals use the ice as a place of attachment in the sense that sessile animals use rocks, but they can cling to it, and find shelter in the cracks.

CURRENTS

Not much is known about the currents in the Arctic Ocean. Evidently there is a general flow across the Pole from somewhat off the eastern Siberian coast out past Greenland. Apparently no large gyral is concerned with the circulation of Arctic Ocean water. There are, no doubt, some large eddies, one of which is within the Beaufort Sea. The waters probably flow westward alongshore, turning oceanward at Point Barrow and returning toward shore at a point perhaps as far eastward as Banks Island. Because of the rapid lessening of the lengths of degrees of longitude, the Cariolis force has much more effect in Arctic regions than in lower latitudes, but just how great this is near shore at Point Barrow is unknown.

A great deal of driftwood lands on the beach at Point Barrow. This wood comes either from the east from the Mackenzie or from

the southwest from the Yukon, which empties into Norton Sound south of Bering Strait. The Mackenzie is probably the major source, and the wood is carried westward to Point Barrow by the current mentioned above. However, the kelp *Nereocystis,* which does not grow north of Bering Strait, was found on the beach at Point Barrow.

The iceberg (pl. 7) mentioned under "Ice" must have come either from below Bering Strait or from the Canadian Archipelago; it could not have come from Greenland, if the theories presented above are correct.

A few facts regarding the currents in the vicinity of Point Barrow have been ascertained. Along the shore from the Point to the southwestward the prevailing current is northeast; to the east it is northwest. These two currents meet off the Point and flow northward, or, more correctly, north-northeast, for the current to the northeast is the stronger, having at times a speed of 3 miles an hour, or more. They are not steady and are somewhat subject to change by winds. In fact, either may be completely reversed, in which case they are never so strong.

At times in going from shore directly to sea, three definite currents were encountered in succession: first, a slow southwest current perhaps half a mile in width; next, a strong northeast current 6 or 8 miles in width; and then a slow westward current 10 or more miles offshore. The extent of the latter was not determined. Many times it was necessary to give up dredging because the current was stronger than winds of 15 to 20 miles an hour and would set the boat at right angles to the wind and broadside to the waves. This occurred especially during offshore winds.

That all water movement is in general to the northeast can be verified by reference to U. S. Coast and Geodetic Survey map 9445, which shows that the ocean bottom to the north and east of Point Barrow is very shallow, owing to the deposition of materials from the eroding shores, for a long distance oceanward.

As mentioned above, the point at Point Barrow has washed back 28 feet in the last four years. At this rate it is reasonable to suppose that the land extended 504 feet farther north in 1880. That it actually did is borne out by the fact that there is now nothing left of the village of Nuwuk, which was inhabited in 1880, but the remains of two sod houses.

Dall, in his report of 1882 (p. 327), corroborates the above observations regarding currents. He states that the currents along the coast from Point Barrow westward are to the northeast with a velocity of

0.75 to 2 knots an hour. The following tabulation was compiled from his data:

Ship	Date	Rate of drift Knots	Remarks
Contest	8-16-71	1.5	
Jireh Perry	8-16-72	2.5	15 miles northeast of Point Barrow
" "	7-20-73	2.0	Off Point Belcher. Strong currents.
" "	8-14-73		Could barely get around Point Barrow because of the strength of the current.

In August 1878 the bark *Coral* experienced a 12-day blow from the east, with a resulting current toward the west-southwest. On the twelfth day, when the wind changed from east to southwest, the current also changed within a few hours, running strong toward the northeast, indicating the general tendency of the current to run toward the northeast alongshore at and to the southwest of Point Barrow.

One day when my boatman Max Adams and I had landed at the Point, I mentioned that the current was very strong toward the northeast. Max, who had spent his life boating and hunting at Point Barrow said, "Oh, yes, sometimes he run like river same way."

Ernest F. Chafe (1918) states that the whaler *Karluk* drifted northwest 2 miles an hour from Camden Bay past Point Barrow. Upon reaching the 75th parallel of latitude, it began a southwesterly drift. The ship was abandoned at 73° N., 178° W., at a 38-fathom depth, 80 miles north of Wrangell Island, 200 miles from Siberia.

Dall also mentions logs of whalers that told of shifting from one side of the Point to the other, depending on wind direction, to escape rough seas. That Dall missed no reference to conditions at Point Barrow that could be obtained from logs of whaling vessels and other sources is shown by his reference to an article in the *Daily Alta Californian* of San Francisco, in which Captain Fisher of the *Sea Breeze* is quoted as saying, "Off Point Barrow a 3- or 4-knot current sets regularly along the land northeastward which does not exist 50 miles off shore."

An interesting phenomenon that was noted by the writer, and one that warrants more study, is the current at Eluitkak Pass (fig. 1, *D*) between the mainland spit and Doctor Island. As was mentioned under "Geology," nowhere is Elson Lagoon deeper than 12 feet. Yet the Pass is 46 feet deep in the center, and the current through it is sufficiently strong to scour out all mud from the bottom, leaving only stones and boulders. To the eastward, however, there are openings everywhere, but no sign of currents between the islands. Why does

the current run out only at Eluitkak Pass? Although each year the Arctic Contractors cut a channel through the mainland sandspit near the west end of Elson Lagoon almost directly opposite Eluitkak Pass, this channel (see *F*, fig. 1) soon fills in.

Currents are important to the animals of the ocean because they have a great effect on the bottom. If there is little current there is mud; if the current is strong, there is rubble. Each of these bottoms supports a different fauna. The entire bottom has ice-borne gravel and boulders, but only where there are strong currents are the gravel and stones bared so that sessile animals may attach to them.

Currents are also of importance in distributing larvae, though there is reason to believe that they play a less important role in distribution in the Arctic than elsewhere. Evidence for this belief will be discussed under "Distribution."

The possibility of a correlation between currents and weather also exists.

TEMPERATURE (OCEAN)

Daily surface temperatures were kept from July 12 to October 8, 1948, and from July 1, 1949, to September 1, 1950. During this time the extremes were a low of −1.8° C. and a high of 7.2° C. (the latter for only a few hours on August 17, 1949), a difference of 9° C. While the ice was out these temperatures were taken from shore by using a long-handled dipper, but during the winter they were taken through a hole in the ice. The water in the hole was always stirred up from below to get the temperature of the water under the ice or, during melting in spring, by taking water from 10 feet below the surface in order to avoid the fresh water. All deep recording thermometers and bathythermograph records show the ocean water below 100 feet to approximate 0.0° C.

The Bering Sea is somewhat warmer than the Chukchi Sea, and it is possible that currents from the Chukchi may affect the temperatures at Barrow from year to year, but much more work is necessary to establish any such effects.

In his report Dall (1882) gives the average month-by-month temperature of the ocean water at St. Michael in Norton Sound. Between October and July this varied from 0.0° to 1.7° C., but the average for July was 13.3° C., for August 13.4° C., and September 9.8° C. It would be expected that these high summer temperatures would affect the Point Barrow region, but there was no warming of the waters there for the 3- or 4-month period. It is possible that most

of the warm water from the region of St. Michael goes to the northwest toward Wrangell Island.

The extremes of temperature experienced by the marine invertebrate animals at Barrow below a depth of 50 feet during the summer of 1948 and the period from June 30, 1949, to September 1, 1950, ranged from a high of 4.1° C. to a low of −1.8° C. recorded, respectively, on September 6, 1949, and July 27, 1950. The variation in temperature at the surface is a few degrees more than that of deeper water. The highest surface temperature in 1948 was 7.0° C. on August 17, but that year floating ice was always present in greater or lesser amounts. In 1949, a surface temperature of 7.0° C. was recorded on August 11, 12, 13, 14, and 16; the highest that year was 7.2° C. on August 17. These temperatures were taken at approximately 5 p.m.; the morning temperature on these days was 6.7° C. These dates were just after the sun began dipping below the horizon. The higher temperatures were very fleeting, usually lasting only a few hours.

The coldest temperature recorded, taken through a hole in the ice, was −2.1° C. from November 13, 1949, until March 22, 1950. From March 23, 1950, to April 16 the temperature was −1.9° C.; on May 30, 1950, it reached −1.5° C., and from then until the time the ice went out it gradually warmed to 0.5° C. In 1949 the surface temperature jumped from −0.4° C. on July 30 to 4.5° C. on July 31. The ice had been gone since the night of July 19.

As explained under the discussion of the natural history of marine invertebrates, there are few animals that are affected by surface temperatures. In general it can be said that the extremes to which the invertebrate animals in the vicinity of Point Barrow are subjected are from −1.8° to 4.0° C., as shown by the writer's records for an entire year and for three summers. This is a range of less than 6.0° C. The following table gives the average monthly records for the time that this investigation was carried on. The twice-daily records for this period were considered too extensive for inclusion in this report, especially since, with the possible exception of some planktonic forms, surface temperature has little effect on the invertebrates of the region.

Table 2 gives the extremes of temperature during the same period covered by table 1.

While the temperature may be 7° C. at the surface, 10 feet down it will be at least 3° or 4° colder. Time and facilities did not permit the routine taking of temperatures at the two most useful depths—50 feet, and on the surface of the bottom.

The frozen ground (permafrost) extends approximately 1,000 feet

TABLE 1.—*Average surface temperature records, Arctic Ocean, Point Barrow, Alaska, August-September 1948, and July 1949 to August 1950*

Year	Month	Temperature °C	Remarks
1948	August	3.30	Floating ice all during summer
	September	—1.06	
1949	July	0.90	No summer ice
	August	5.50	
	September	2.85	
	October	0.02	
	November	—1.80	
	December	—2.00	
1950	January	—2.00	
	February	—2.00	
	March	—1.95	
	April	—1.90	
	May	—1.80	
	June	—0.90	
	July	1.30	No summer ice
	August	5.70	

TABLE 2.—*Highest and lowest surface temperatures, Arctic Ocean, Point Barrow, Alaska, August-September 1948, and July 1949 to August 1950*

Year	Month and day	Highest °C	Month and day	Lowest °C
1948	Aug. 17	7.0	Aug. 28, 30, 31	—0.5
	Sept. 1, 2, 3, 27	—0.5	Sept. 18, 23, 24, 25	—1.5
1949	July 31	4.5	July 29	—1.3*
	Aug. 17	7.2	Aug. 27	2.3
	Sept. 1	6.0	Sept. 26, 27	—0.1
	Oct. 1	1.6	Oct. 24, 27, 31	—1.8
	Nov. 3	0.1	Nov. 17	—2.1
	Dec. 17	—1.9	Dec. 2, 8, 11	—2.1
1950	Jan. all month	—2.0	Jan. all month	—2.0
	Feb. " "	—2.0	Feb. " "	—2.0
	Mar. 1 and 22-31, incl.	—1.9	Mar. 2-21, incl.	—2.0
			Apr. 1-16, incl. and 26-30, incl.	—1.9
	Apr. 17-25, incl.	—1.8		
	May 30, 31	—1.5	May 3-10, incl.	—1.8
	June 20-30, incl.	0.5	June 1, 9	—1.5
	July 24	2.5	July 31	—0.2
	Aug. 19	6.5	Aug. 29	1.2

* Ice floes grounded alongshore.

down. In a well on the beach near Point Barrow it was 960 feet deep. How far this permafrost extends out under the ocean is not known, but as the shoreline at and adjacent to Point Barrow is evidently receding southward and as the ocean water is generally colder than freezing, it ought to be as far out as the shore has receded.

A strong offshore wind would cause considerable upwelling, and on one occasion when it lasted nearly three days, the continuous upwelling brought several deep pelagic animals, including two specimens of the octopus *Cirroteuthis* sp. near shore.

SALINITY

The salinity of the water of the Arctic Ocean is slightly lower than that of other seas. This is attributable to several factors, chief of which are the vast amounts of fresh water flowing into the Arctic and the low rate of evaporation.

Drainage from 4.5 million square miles of territory affects the salinity of the water, but not so much as would be expected with so many large rivers emptying into the sea. It may have more effect to the north of the Siberian coast, where there apparently is a tendency for the waters of Bering Strait to turn out toward Wrangell Island and thus counterbalance the effects of the fresh water from the Siberian streams. Also, it should be remembered that the Arctic Zone is a desert, the precipitation at Point Barrow being only about 4 inches a year, including the snowfall.

Table 3 gives the highest and lowest salinities recorded for each month covered by this investigation.

A comparison of the highest and lowest salinities during August of 1948, 1949, and 1950 is of interest. Ice floes, which were present all summer in 1948, kept the salinity lower than in the summers of 1949 and 1950, when no ice was present. These melt from the bottom and unexposed sides as well as from the top and exposed sides, so that the salinity of the water would be lowered around the floes to the depth that they extend below the surface.

However, the majority of the invertebrates of the Arctic Ocean appear to be adapted to considerable change in salinity and it is only when they come in contact with surface water of very low salinity as the result of melting ice that they succumb. Under "Phylum Chaetognatha" it will be noted that the arrowworm *Sagitta elegans* was able to survive when the salinity of the water reached 15.22 parts per thousand but was killed when it dropped to 5.81. Also, under Annelida mention is made of the polychaetes that were killed during the short time required to haul the dredge through the few feet of surface water

of very low salinity. The lower salinity of the water at Eluitkak Pass is probably the main reason for the absence of echinoderms in that locality. It would be interesting to test the tolerance to lowered salinities of a number of Arctic marine invertebrates and of the same species in the North Atlantic and the North Pacific, and compare the results.

The average of the highest salinities is 33.54 parts per thousand. This no doubt approximates, or is perhaps a little higher than, the

TABLE 3.—*Highest and lowest surface salinities, Arctic Ocean, Point Barrow, Alaska, July-September 1948, and July 1949 to August 1950*

Year	Month and day	Highest	Month and day	Lowest
1948	July 28	32.37	July 17	5.26
	Aug. 7, 9, 11, 20	30.43	Aug. 4	23.79
	Sept. 27	34.30	Sept. 1	27.67
1949	July 26	35.00	July 13	4.20
	Aug. 24	34.30	Aug. 3	30.40
	Sept. 26	34.20	Sept. 1, 12	32.00
	Oct. 1	34.20	Oct. 21	30.11
	Nov. 8	34.52	Nov. 2	31.10
	Dec. 25, 29	34.30	Dec. 6	30.90
1950	Jan. 6	34.00	Jan. 3	32.60
	Feb. 2	33.40	Feb. 1	28.60
	Mar. 16	32.60	Mar. 2, 5, 6	31.80
	Apr. 7	32.50	Apr. 19	31.80
	May 3, 24	32.40	May 14, 21, 26	32.00
	June 6	33.40	June 16	1.40*
	July*			
	Aug. 4	33.70	Aug. 7	28.00

* Because of the melting ice, the surface water during the latter half of June and until the ice went out in July did not give a true picture of the salinity of the ocean, for it was only slightly salty while the water 10 ft. or more below the surface was much more saline. It was impossible to get out more than once or twice where samples of deeper water could be taken.

salinity of the deeper waters of the ocean off Point Barrow. The average for these deeper waters can be determined only by extensive deep-water sampling by a ship with oceanographic equipment.

LIGHT

On March 22 and September 21 the length of time the sun is above the horizon is equal to the time it is obscured. There are, however, many more than 12 hours of daylight. The sun rises and sets at such a small angle to the horizon that there are 16 hours of daylight on these dates. On June 22 there are 24 hours of daylight, and on December 21 there are about 2.5 hours of twilight. When the sun is on the meridian at noon on June 22 it is 42°10′ above the horizon and at

midnight it is still 4°50′ above the horizon. It is continually above the horizon from May 17 to July 24 and continually below it from November 19 to January 20. Because of the refraction of light at the horizon, the sun can still be seen when it is actually below the horizon. Twenty-four hours of daylight does not mean that there are 24 hours of sunlight. During much of the summer of 1948 there was sunshine on the average of about one day a week. The sun may be obscured by clouds all day and appear at 2 a.m. The amount of light depends on the time of day the sun shines as well as on the length of time it shines. If the sun is obscured during the time it is highest and shines when it is near the horizon, there is less light than if it were visible when at its highest and obscured when near the horizon.

There are several factors that influence the amount of light in the ocean waters off Point Barrow:

1. The amount of sunlight.
2. The amount of daylight.
3. The angle with which light enters the water.
4. The wind.
5. The weather ceiling.
6. The amount of ice.
7. The amount of plankton.
8. The amount of sediment in the water.

1 and 2.—Light may be one of the major factors affecting the life of planktonic invertebrates in the Arctic Ocean. Though higher than generally supposed, the metabolic rate of marine invertebrates is relatively slow, thus enabling these animals to live longer under adverse conditions than many other animals. Many of the more active animals, for example certain crustaceans and gastropods, store oil droplets during the optimal conditions of late summer and early fall to tide them over the winter.

Light has little or no effect on the invertebrate bottom animals, because most of this fauna is below 100 feet. The detritus on which these animals feed is not greatly affected, if at all, by light, bacterial action being more dependent upon temperature. As temperature is so uniform in the Arctic, these animals have a constant supply of food independent of light, and are therefore adapted to continuous darkness. The planktonic animals are adjusted to a long period of semi-darkness.

In general the light entering the waters of Point Barrow is by no means so intense as that in more southern regions, but, being present over longer periods, it is sufficient for the photosynthesis of diatoms, which proceeds at an optimal rate in subdued light. Light is exactly

the same for any given latitude in all parts of the Arctic Ocean. Even at the Pole, where the sun alternately shines for six months and is below the horizon for six months, periods of twilight help to shorten the time of total darkness to the extent that the growth of diatoms can proceed throughout eight or nine months of the year.

3.—The angle at which the sunlight enters the water ranges from 0° to 42°10′. The greater the angle of the waves to the horizontal the higher the angle at which light penetrates on the side toward the sun.

4.—The wind blows almost constantly at Point Barrow. Since wind causes waves, the stronger the wind, the higher the waves, and consequently the more the light penetration, to a limited extent. When waves are sufficiently high to form whitecaps, light penetration no longer increases with the strength of the wind. Prevailing northeast winds set up wave surfaces toward the sun when it is at or near its maximum height.

5.—The weather is nearly always cloudy during the months of most daylight. This low ceiling has considerable effect on the penetration of light. The fog layer over the ocean is seldom over 20 or 30 feet high. However, since the optimal condition for metabolism in diatoms is subdued light, it is evident that the Arctic is an excellent place for this group, at least during nine months of the year. Certain diatoms were found all winter long under the ice but during midwinter even those that were present were not abundant.

6.—As has been said under "Ice," a considerable amount of the ocean surface is frozen over. In addition to the shore ice, which extends 3 to 5 miles to sea, there is a great deal of floating ice, in which leads come and go. Nevertheless, during winter the ice cover ranges from almost 100 percent over a great portion of the Arctic Ocean to at least 75 percent alongshore, that is, to a distance of 25 miles—the limit of the present investigations. In summer, however, there is a great deal of open water alongshore, and seldom, if ever, is more than 25 percent of the surface covered by ice. The ice, like the weather, is never the same from day to day or from season to season.

At least in the upper surface of the water the ice has much less effect on light than might be supposed. In this investigation both ice houses and tents were used in work on and through the ice. Within a tent in January, even when the ice is 5 feet thick, a greenish glow comes through it from below. The snow cover reflects light but at the same time glows with transmitted light, and much light enters through it into the ice and water below.

7.—The effect of the penetration of light on plankton has been dis-

cussed in too many oceanographic papers and books to need elaboration here. Plankton is very abundant at Barrow for that period when there is open water, usually from May to October. In winter, after a hole is made in the ice, the bottom of the ocean can be seen plainly through 16 feet of water.

8.—Sediment is more important than at first might be supposed, for it is a factor in decreasing the penetration of light. The water is muddy to a varying degree almost all summer. This muddiness extends out to sea for a distance of 20 miles or more; at least it is visible to this distance from a plane, and bush pilots flying to the east and west of Point Barrow report this muddy water along the coast for several hundred miles in each direction.

OXYGEN

Oxygen is probably never a problem in the Arctic. Cold water can hold more than warm water, and the high photosynthetic rate of diatoms in summer, waves in the open water, and convection currents keep all parts of the Arctic Ocean well supplied with oxygen.

TIDES, WINDS, AND STORMS

There is no Coast and Geodetic Survey record for tides at Point Barrow, but they are not supposed to exceed 6 or 8 inches. However, wind tides of 3 feet or more are experienced on occasion. Ray (1885) made a 112-day record without missing a day beginning February 26 and ending June 17, a total of 5,376 observations. His gauge was 100 yards from shore in 17 feet of water (no allowance for vertical movement of ice). The average daily variation was 6 to 7 inches, but the level did vary up to 3 feet. Wind tides are mainly responsible for breaking up the ice sheets and piling the ice into ridges.

Because of the unpredictability of windstorms, wind tides may occur at any time, particularly at Point Barrow. As one Arcon employee said when someone spoke of the highly variable character of the weather, "Oh, yes, we make it here and try it out before we send it to all parts of the country."

Windstorms were of importance for two main reasons. No dredging could be done in open water when the wind was above about 15 miles or when it drove the ice to or from shore or piled it up into ridges. The combined effect of wind and current might cause the ice near shore to move in one direction while that farther from shore moved in the opposite direction (see "Currents").

The greatest effect of the wind tides was on the animals within the

surf zone. Though few in species, these animals were washed out in great numbers and many of the records of alongshore marine animals were obtained by patrolling the beach after a windstorm.

In winter, stations could be located exactly by survey lines run over the ice, but in summer, because of the prevalence of fog, strong currents, and wind, it was much more difficult to go to a station or to return to a former site.

The northwest current, which turns north at Point Barrow, may have a great deal to do with the deep channel that always exists at Eluitkak Pass. The tendency to turn right, with back pressure from the Beaufort Sea gyral, fills Elson Lagoon, and its only outlet is through Eluitkak Pass. The channel that is dug every year by the Arctic Contractors closes quickly because of the strong alongshore current northeast toward the point. During the writer's stay at Barrow base, the heaviest swells and resulting heavy surf came from the general direction of north-northwest to northwest.

GENERAL DISCUSSION

DISTRIBUTION

One of the main objectives of the study of the marine animals was to determine the species common to Point Barrow and other regions of the Arctic and those common to the Arctic and the North Atlantic and to the Arctic and the North Pacific.

Distribution is to a great extent dependent upon currents (see "Currents"). However, currents are not the only major factor involved. Most students of marine ecology fail to give due credit to the vast scope of geological time for the role it plays in the distribution of species; they have had sufficient time—a billion years of it—to spread to all similar parts of all oceans. Of course, not every species will be found in every part of every ocean. Environments are so different that speciation proceeds with adaptive deployment. If it were not for environmental differences and habitat preferences, no doubt all species would be found in every ocean. After all, most phyla, classes, and orders are worldwide in distribution. Even some species (see "Nemertea") are practically worldwide in their distribution, indicating a very stable inheritance.

The concern here is with the distribution of Arctic Ocean animals where environmental factors are the same, or nearly the same, for all localities of the continental shelf. All species conform to the curve of normal distribution for any factor and the curve is different for each factor. Species of marine animals that have a wide range of tolerance

to temperature, for example, would become distributed from the Arctic to North Atlantic and North Pacific regions more readily than a species that has a very narrow range of tolerance to the same factor. When the same species of marine animal is found in both the Atlantic and Pacific, it has migrated through the Arctic unless brought around on a ship bottom or sent overland with oyster spat or other transplants.

The usually accepted premise is that the populations of Arctic marine animals have come from more southern waters. Is this supposition justified? Time is so vast in its scope that little is known of conditions in the Arctic in ages past. Certainly it has been warmer in the Arctic than now—also colder. Perhaps most Arctic marine species did come from the southward, but it is possible that some North Atlantic species and some North Pacific species came from the Arctic; at least, if they are identical in both these regions they must have migrated through the Arctic Ocean. Distribution of marine invertebrates is one phase of the process of evolution, and the collection of data that will support or disprove theories of distribution in the Arctic is essential to determine what part it has played in the establishment of present-day deployment and species. It is hoped that this report will offer some evidence that will assist in arriving at conclusions.

Within a human generation animals introduced to new coasts have become distributed 1,000 miles or more. For example, within about 25 years since it was introduced from Europe, a littorine snail has spread along much of the east coast of the United States. If it deployed but 5 feet a year, how long would it take a species to become circumarctic? The 75th parallel is approximately 1,250 miles long. Since deployment takes place in all directions (in this surmise only two, east and west, are considered), the time required for meeting on the opposite side would be equal to 625 miles times 5,280 feet divided by 5 feet or approximately two-thirds of 1 million years. There are 1,000 million in 1 billion, or 1,500 times two-thirds of a million—in other words, the required time would be 1,500 times as long as is necessary.

Practically all marine invertebrates have either swimming larvae or means of locomotion as adults, and for such animals 5 feet a year is far too low an estimate of the rate of distribution. Even those sessile animals without free-swimming larvae certainly can average, over a period of years, more than 5 feet a year. At some stage the larvae become detached from the parent, and as tiny animals they are moved about by the activities of other animals before becoming sessile. In

the Arctic such larvae or even small to adult animals may be pushed many yards by ground ice. To a depth of 100 feet or more in the bottom off Point Barrow there are holes (that have been gouged out by ice) 6 feet or more below the surrounding bottom level. Although they are uncommon off Barrow, icebergs (pl. 7) grind and shove material along the bottom for a mile or more to where the water is about 200 feet deep. No doubt if one were able to live among the animals on the floor of the Arctic Ocean shelf, other factors contributing to distribution would be found.

Today ship bottoms provide a medium for the dispersal of species. This factor is more important outside the Arctic Ocean than within it, although whalers have been anchoring off Point Barrow and farther east for over a hundred years. Some whaling vessels froze in at Herschel Island for three winters in succession before obtaining a cargo of oil and whalebone. A ship bottom can become quite foul in six months. How many Arctic animals would such a ship carry into the Pacific?

The conditions in the Arctic Ocean are so stable and show such a small degree of variation that an animal living in one place on the Continental Shelf could find equal optimal conditions at any other point with similar bottom within the ocean on the shelf. Nothing is known of the fauna of the deeper Arctic Ocean bottom.

To verify my theory that the Continental Shelf of the Arctic Ocean is a unit environment, it would be necessary actually to measure ecological factors and sample the animal population at a sufficient number of places to show that all equivalent parts of the shelf support the same associated types.

A common practice among marine ecologists is to consider the ocean bottom as unchanging aggregations of animals. Nothing is farther from the truth. In checking the bottom off Newport Bay, Calif., near the Kerckhoff Marine Laboratory, the writer has found that between 1948 and 1952 the type of animals once found in certain regions has entirely changed. At Point Barrow there was an indication of why the bottom there would change materially over considerable areas (see "Winter Dredging"), although the general picture of the region and the whole Continental Shelf of the Arctic Ocean would remain the same. In the fall of 1949 a layer of mud killed off what most people would call an anemone-*Strongylocentrotus*–*Psolus* association. Whether it will come back the same or as a *Strongylocentrotus*–*Psolus*–anemone, or a *Psolus*–anemone–*Strongylocentrotus,* or some other combination of the three is anybody's guess. Perhaps it will become something entirely different, such as a *Balanus crenatus*–

Hiatella association. However, the proportions of these animals throughout the Arctic shelf will remain fairly constant over long periods of time—for a million years or more if no great climatic change takes place. Establishing a balance among the fauna of the Arctic Ocean has required many millions of years, and what occurs in a small locality like Point Barrow has little or no bearing on this balance. If one is to have a better understanding of the evolutionary processes concerned with the marine animal population, distribution and deployment from the point of view of the entire Arctic shelf must be considered.

A comparison of the records obtained at Point Barrow with those of other investigators of the Arctic Ocean shows that such factors as climate, vegetation, geology, ice, currents, temperature, salinity, light, oxygen, tides, wind, and storms are quite uniform for the entire area of the shelf. Therefore a marine animal adapted to one place on the shelf is adapted to all regions of the shelf. If it can be proved that animals found in one locality of the Arctic shelf are found in all similar localities, then a knowledge of distribution is most important to our understanding of how the fauna of the Arctic shelf became established and what to expect in future evolutionary trends.

The greatest merit of the Point Barrow investigation has been its contribution toward verifying these theories. The distribution of all adapted forms is proving to be quite uniform, although many more localities around the basin need thorough investigation. An intensive survey of the Continental Shelf bordering the Laptev Sea would be of value equal to the one done at Barrow.

If a comparison can be made with Scandinavian collections in order to eliminate uncertainties regarding names, a table could be made showing species common to both Point Barrow and the North Pacific and those common to Point Barrow and the North Atlantic. Such a table would be of great value in furnishing evidence of the rates of distribution between the three areas. It would help to answer such questions as the following:

1. Does the continuous flow of ocean water northward through Bering Strait inhibit the distribution into the North Pacific?
2. Is the rate of distribution into the Arctic from the Atlantic greater than from the Pacific into the Arctic?
3. Is there any distribution of strictly Arctic animals from the polar regions into the North Atlantic?
4. Is there any evidence that ship bottoms play a part in distribution?
5. Is there evidence to show that it is easier for distribution to proceed from a warmer to a colder habitat or vice versa?

Distribution depends more on the larvae's than the adults' becoming acclimatized to new environments. If marine animals can do anything well it is to reproduce—sometimes at the rate of half a billion per year (Galtsoff, 1930; MacGinitie, 1934). Because of the advantages of constant immersion in sea water and an enormous rate of reproduction the distribution of marine animals into or out of the Arctic should not require a long evolutionary process. However, this would be different for each species just as the rate of reproduction is different for each species; and the rate of evolutionary change is not necessarily proportional to the number of offspring. Some groups of animals are much more adaptable than others in their ability to evolve into new species. Some species live a few years; others many. Some groups (e.g., brachiopods) are in general inclined to stick to an orthogenetic line while others (e.g., certain snails) become adapted readily to a new environment. In other words, evolution is a slow process in some groups and relatively rapid in others, with corresponding effects on distribution. Distribution, therefore, furnishes as much information regarding evolutionary development as do almost any other data.

FOOD

The writer classifies the food of marine animals under five headings, which are listed in the order of their relative abundance: 1, Plankton; 2, detritus; 3, other animals; 4, debris; 5, seaweeds. Actually a sixth could be given—self-cultured algal cells, used by the flatworm *Convoluta roscoffensis* and the clam *Tridacna*.

Plankton furnishes food for one great group of marine animals—the pelagic or free-moving marine animals living in the ocean above the bottom. This group, from the tiny microscopic larvae to great sharks, is dependent directly or indirectly on the diatom pastures (which form an important part of the plankton) of the oceans. In the waters off Barrow base plankton is extremely plentiful in summer and great swarms of euphausiids (krill), mysids, pteropods, and copepods are present. This abundance of food accounts for the migration of the baleen whales into the Arctic each summer. Since plankton is not so abundant in winter, many invertebrates as well as vertebrates of the Arctic store food in the form of oil or fat.

Another great group feeds on detritus. It includes the burrowers and semiburrowers of the ocean bottom, together with many sessile animals that are anchored in the mud. In rocky regions where the bulk of animal life is sessile, both plankton and detritus may be used indiscriminately, for both consist of finely divided food particles.

Plankton is mainly diatoms, and detritus is mainly bacteria and microscopic plant material being used for food by bacteria. Seaweeds per se are little used as food, but when they are broken down to microscopic or nearly microscopic size and are decomposing they, along with the great bulk of bacteria feeding on them, form detritus. Practically all bottom-dwelling animals feed on detritus. Detritus even forms coatings on the surfaces of sand grains. Therefore any mud- or sand-ingesting animals live on detritus, and many are equipped with special devices for straining this from bottom surfaces with a minimum intake of mud or sand. The more finely divided the sediment, the greater the surface, and, since marine bacteria live only on surfaces, the greater the opportunity for bacteria to exist. Therefore it can be said that in general mud is richer in detritus than sand. The richness of the detritus depends on the settling out from the water of organic material and, therefore, detritus is richer close to shore, especially in the vicinity of river mouths. The suspended material in the muddy water of the ocean bottom is mainly detritus, which is constantly being stirred up by the movements of animals, by currents, or the activities of the detritus feeders themselves. Near shore it is churned up by the surf. Even some vertebrates, such as the shovel-nosed shark or bat stingray, are indirectly dependent on detritus for food, as they dig for and feed on clams and worms that feed directly on detritus.

As there are no seaweeds to speak of in the region of Barrow, the writer wondered where the detritus came from, but in the fall of 1949 this question was answered by the entrance of great quantities of tundra plants into the ocean waters from the eroding shores. Any plant material will form food for marine bacteria and, therefore, will produce detritus. Within a month enough plant material to supply detritus for several years was washed into the ocean and drifted over a great area. There is certainly an overabundance of detritus in the Arctic off Barrow, and the food of Arctic animals is far in excess of their needs.

The feeding habits of Arctic invertebrates, with examples of animals living on the different types of food, may be summarized as follows:

All free-moving invertebrates surrounded entirely by water above the bottom are *plankton feeders,* directly or indirectly. Conspicuous among these are jellyfishes, ctenophores, and certain amphipods.

The majority of the bottom dwellers are *detritus feeders,* directly or indirectly. These include echiuroid and sipunculid worms; certain polychaete worms such as *Arenicola,* cirratulids, and terebellids; clams, bryozoans, and Foraminifera.

Predators, or those feeding on *other animals,* are either pelagic or bottom-dwelling, but seldom, if ever, both. The first are indirectly dependent on diatoms, and include jellyfishes, ctenophores, and chaetognaths. The latter are indirectly dependent on detritus, and include starfishes, flatworms, sea anemones, certain isopods, amphipods, and crabs, and certain snails such as *Natica* and *Polinices.*

Debris feeders, or scavengers, are bottom dwellers feeding at the surface on larger particles of plant or animal debris. These are exemplified by sea urchins, crabs, hermit crabs, and some snails.

Seaweed feeders are very rare.

No *commensal algal* feeders are known to live in the Arctic.

ABUNDANCE OF ANIMALS

The abundance of marine animal life at Point Barrow, especially in the rubble zone, was little short of astonishing. There are far fewer species of marine invertebrates in the Arctic than in the equatorial, tropical, or temperate regions, but in general individuals of species occur in far greater numbers. For example, as has been mentioned elsewhere, there are swarms of mysids, euphausiids, pteropods, and copepods. In addition to these, there are great numbers of jellyfishes (*Aurelia* and *Cyanea*), ctenophores (*Beroë* and *Mertensia*), and chaetognaths, although the last are probably often as abundant in the north-temperate waters as they are in the Arctic. Individuals of a number of species of bottom dwellers are numerous; and in certain areas of the rubble zone there are large numbers of sea anemones, sea urchins, sea cucumbers, bryozoans, barnacles, and sponges. Where the stones of the rubble are small, the clam *Hiatella arctica,* barnacles, and bryozoans are extremely abundant.

Because of the difficulty of dredging in the blue-mud zone it is impossible to give any estimate of the abundance of animals living within the mud, but on the surface were found two species of crabs, *Chionocetes opilio* and *Hyas coarctatus alutaceus,* and one hermit crab, *Pagurus trigonocheirus,* that were particularly abundant. During the summers of 1949 and 1950 when the ice was far offshore, the heavy surf disturbed the bottom sufficiently to furnish some idea of the marine population in this mud zone, for certain burrowing forms were washed ashore in large numbers. Among these were the echiuroid worm *Echiurus echiurus alaskanus,* the polychaete *Arenicola glacialis,* two species of burrowing anemones, and two species of mud-dwelling tunicates.

Two species of amphipods, *Melita formosa* and *Anonyx nugax,*

were washed ashore in such immense numbers that they formed windrows along the beach.

In order to obtain a more objective idea of the abundance of marine invertebrates at Point Barrow, a rock with an average amount of growth was measured, and the animals living on it were removed, preserved, and then identified and counted. This rock, which was dredged on September 6, 1949, from a depth of 217 feet, was 22.5 cm. long, 13.5 cm. wide, and 6.7 cm. thick. The following is a list of the animals taken from this rock:

Animals from measured rock	Number and description
Coelenterates (4+ sp., 11+ spec.)*:	
Hydroids	Several colonies
Eunephthya rubiformis	7 colonies (measuring, in mm., when contracted, 8 x 4, 8 x 3, 7 x 4, 6 x 5, 5 x 5, 4 x 4, and 4 x 3)
Sea anemone	1 (9 mm. high by 10 mm. diam.)
Nemerteans (3 sp., 6+spec.):	
Tetrastemma sp.	2+
Amphiporus pacificus	3+
Micrura alaskensis	1
Bryozoans (several sp.):	Several encrusting colonies
Annelids—Polychaetes (21 sp., 65 spec.):	
Polynoidae	
Gattyana cirrosa	3
Harmothoë extenuata	4
Sigalionidae	
Pholoë minuta	1
Syllidae	
Autolytus alexandri	1
A. fallax	1
Eusyllis blomstrandi	1
Exogone dispar	2
Sphaerosyllis erinaceus	12
Syllis cornuta	5
S. fasciata	5
Phyllodocidae	
Eteona flava	1
Mystides borealis	1
Spionidae	
Polydora caulleryi	4
Cirratulidae	
Chaetozone setosa	6
Cirratulus cirratus	7
Capitellidae	
Capitella capitata	3
Terebellidae	
Amphitrite cirrata	1

* sp. = species; spec. = specimens.

Animals from measured rock	Number and description
Annelids—continued	
Terebellidae—continued	
Lanassa venusta	1
Proclea graffi	2
Sabellidae	
Chone duneri	2
Sabella crassicornis	2
Echinoderms (1 sp., 1 spec.):	
Ophiuran	1 (young, with disk 1.5 mm. diam.)
Crustaceans (7 sp., 14+ spec.):	
Cirripedes	
Balanus crenatus	Numerous specimens 1 mm. across base; 2 (4 mm. and 2.5 mm. across base)
Copepods (1 sp., 2 spec.):	
Doropygus sp.	2 (1 female in each of two tunicates, *Boltenia echinata,* measuring 25 x 17 mm. and 18 x 14 mm.)
Amphipods (5 sp., 53 spec.):	
Maera danae	2 (1 male, 1 ovig. female)
Protomedeia fasciata	1
Ericthonius hunteri	4 (2 males, 2 females with young just ready to hatch)
Unidentified	1
Caprellid	1
Mollusks (2 sp., 3 spec.):	
Hiatella arctica	2 (4.3 mm. and 7.5 mm. long)
Lepeta caeca	1 (8.5 mm. long)
Tunicates (6 sp., 41 spec.):	
Didemnum albidum	8 colonies (measuring, in mm., 18 x 12, 17 x 10, 14 x 8, 12 x 7, 11 x 8, 11 x 7, 8 x 7, 5 x 5
Dendrodoa sp.	1 (52 x 22 mm.)
Styela sp. (or *Dendrodoa* sp.)	4 (15, 11, 10, and 7 mm. high)
Styela sp. (or *Dendrodoa* sp.)	13 (20, 17, 15, 15, 14, 11, 10, 9, 8, 7, 2.5, 1.5, and 0.75 mm. high)
Chelysoma macleayanum	3 (21 x 14, 18 x 14, and 5 x 4 mm.)
Boltenia echinata	12 (length x height, 28 x 19, 25 x 17, 19 x 15, 18 x 22, 18 x 14, 17 x 21, 15 x 20, 11 x 18, 7 x 7 mm., and 3 young individuals from 5 to 6 mm. long)

One face and four sides of this rock formed the habitat for more than 200 individuals and colonies representing over 53 species. These were growing on a surface of 786.15 square centimeters or approximately 125.78 square inches, a surface equivalent to an 11-inch square.

Another indication of marine invertebrate abundance was the identi-

fication by Dr. Osburn of 21 different species of bryozoans from two faces of a single valve of *Pecten islandicus.*

With such a dense population, attachment space is at a premium; consequently almost no sessile animal or colony of animals is without its quota of other animals growing upon it. Hydroids commonly have other hydroids, bryozoans, foraminifers, and tunicates, such as *Molgula griffithsi* and *Boltenia ovifera,* growing on them. The asexual form of the syllid worm *Autolytus fallax* was frequently found with its tube attached longitudinally to the chenille-like stems of the hydroid *Lafoeina* (possibly *maxima* Levinsen). The long, straw-colored stems (up to 150 mm. in length) of a species of *Tubularia* were often supported by the mud-tube nests of the amphipod *Ericthonius tolli* forming a mass surrounding the stems. In one such mass a sipunculid, *Golfingia margaritacea,* was living in one of the mud tubes, and an annelid, *Thelepus cincinnatus,* was living in its coarse-sand-encrusted tube twining among the stems of the hydroid.

Both erect and foliaceous, as well as encrusting, bryozoans are favorite places of attachment for foraminifers, hydroids, other bryozoans, and tunicates. A colony of *Eucratea loricata,* dredged from 213 feet, had the following animals growing on it: Foraminifers; the bryozoans *Hincksina nigrans* and *Costazia nordenskjoldi;* caprellids; a tunicate, *Styela rustica macrenteron,* that was 6.1 mm. long; and a small clam, *Hiatella arctica.*

Tunicates also afford a place of attachment for a variety of animals. The tunic is sufficiently plastic for foraminifers to form depressions to fit their tests. On a specimen of *Dendrodoa* measuring 35 by 16 mm., taken from a depth of 130 feet, the following animals were found: One colony of the bryozoan *Eucratea loricata* 22 mm. high; several colonies of the compound tunicate *Didemnum albidum,* 3 to 5 mm. in diameter; nematodes; foraminifers on the tunic of *Dendrodoa* and on the attached *Eucratea;* two small *Dendrodoa;* one cirratulid, *Chaetozone setosa;* one colony of the bryozoan *Tubulipora flabellaris;* one hydroid colony; one sponge spreading over *Eucratea;* one sponge on the *Dendrodoa;* one small clam; and several species of encrusting bryozoans.

Even nonsessile animals often furnish a place of abode for other animals. Snails of the genera *Buccinum, Neptunea, Volutopsius,* and *Boreotrophon* seldom are without a colony of hydroids (*Hydractinia*), bryozoans, or barnacles growing on their shells.

The legs and carapaces of the crab *Hyas coarctatus alutaceus,* especially the ovigerous females, furnish places of attachment for many sessile forms, which in turn furnish refuge or places of abode for still other animals. An ovigerous female taken on September 9,

1948, at 80 feet was carrying on its carapace colonies of the bryozoan *Dendrobeania murrayana,* colonies of three or four species of calyptoblastic hydroids, and at least one species of gymnoblastic hydroid. From two other ovigerous females taken in this same haul the following animals were taken: 2 species of amphipods (4 or 5 individuals); 1 pycnogonid; 1 four-legged pycnogonid larva; 3 or 4 small annelids, *Eusyllis blomstrandi* and *Exogone naidina* (one in the eye socket); colonies of the bryozoans *Tricellaria erecta* and *Eucratea loricata;* 3 caprellids; and colonies of several species of hydroids. The crabs were completely covered and concealed by their epifauna. A male with a carapace 17 mm. long that was taken on September 6, 1949, at 217 feet had several small colonies of the octocoral *Eunephthya rubiformis* on its carapace. An ovigerous female taken on October 14, 1949, at 175 feet, had the following on its carapace and legs: Young barnacles 1 mm. in diameter; 1 *Balanus crenatus* 10 mm. in diameter; nematodes; caprellids; the annelids *Spirorbis spirillum, Pista maculata* (small), and *Harmothoë extenuata;* colonies of several species of hydroids; foraminifers; and the bryozoans *Tricellaria erecta, Dendrobeania murrayana, Scrupocellaria scabra* var. *paenulata, Hincksina nigrans, Lichenopora verrucaria, Eucratea loricata,* and *Callopora craticula.*

STORAGE OF OIL

A common occurrence among Arctic marine animals is the storage of oil within their bodies for the purpose of tiding them over the winter or for producing during the winter sperm and eggs that can be laid at the beginning of the open season. This phenomenon was especially noticeable among the copepods, for they are small and often so transparent that the oil droplets could be seen through the integument. Toward the end of the open season more and more oil droplets were observed within the copepods, and, conversely, in April the oil droplets began to decrease in number and size. Some copepods taken on May 2 were still well supplied with oil droplets. By the latter part of June these animals were so transparent that they seemed to consist of nothing but the integument—not a single oil droplet remained.

The practice of storing oil is no doubt as common among the amphipods as among the copepods, but the larger size and usually more opaque integument of the amphipods make the oil droplets invisible or more difficult to see. On October 4, 1949, many females of *Anonyx nugax* washed ashore. They had just molted, and the new integument was sufficiently transparent to reveal many oil droplets

in their bodies. In three out of six females of this species taken on January 27, 1950, oil droplets were conspicuous. Similarly, of three females of *Weyprechtia heuglini* taken on June 23, 1950, the two largest were developing marsupiums and their bodies were filled with oil. This oil was undoubtedly being used in producing eggs that could be laid when the marsupiums were fully developed.

The shrimp *Eualus gaimardi* was an excellent animal in which to observe the storage of oil and its subsequent use. It was present in practically every dredge haul and in sufficient numbers to lend value to the observations made on it. Its integument is always more or less transparent, but in the fall specimens of this shrimp were so filled with stored food that they were quite opaque. From February until July specimens were taken through the ice by means of screen traps. The first specimens taken showed small ovaries in the process of developing. In specimens taken on subsequent months the ovaries were larger and larger and the shrimps became more and more transparent as the amount of stored oil diminished. By the end of June the ovaries were filled with well-formed, distinct eggs and the bodies were so transparent that there seemed to be nothing within them except the masses of eggs. A soft-shelled female was taken on July 22, 1950, and on August 1, 1950, a total of 15 ovigerous females with eggs in very early stages of development and another female that was obviously just ready to lay its eggs were collected.

An analysis of the oil content of various animals throughout the year would undoubtedly reveal that the storage of oil is a common practice and is developed to a high degree among Arctic marine invertebrates.

REPRODUCTION PHENOMENA

Although years would be required to obtain a knowledge of the methods of reproduction, the egg-laying season, and the size of the eggs of the animals collected, a few facts became evident in the short time devoted to this phase of the project.

Perhaps the most noticeable of these reproductive phenomena is the tendency among Arctic marine invertebrates to brood their eggs or to provide some other method of protecting them until the embryos develop either into large larvae or young animals similar to the adult. Thorson (1936) has already observed the practice among Arctic gastropods of laying eggs in capsules or in masses of jelly in which the young develop either to the crawling stage or to a late embryonic state with a shortened pelagic life, in marked contrast to the tendency among temperate, equatorial, and tropical species to lay smaller eggs

that produce embryos requiring a relatively long pelagic life. Growth of nonpelagic embryos to an advanced stage is accomplished by the production of large eggs, or eggs from which the embryos develop within the mother, or by the feeding of embryos on nurse eggs or on a nutritive white material.

Capsules and masses of jelly containing snail eggs were abundant and varied at Point Barrow. Few gastropod larvae were observed in the plankton. Most of the data collected on the breeding season of the gastropods are contained in table 4 (p. 41).

At Point Barrow other invertebrates besides snails brood their eggs. The large chaetognath *Eukrohnia hamata* was observed brooding its eggs until the young were 3 mm. in length. No other instance of the brooding of eggs has been reported in this group of animals.

Several of the polychaete worms carry their eggs or incubate them in some manner. *Autolytus fallax* carries its eggs ventrally in an egg sac (usually one, sometimes two), and *A. alexandri,* according to Wesenberg-Lund (1947), carries its eggs ventrally in two egg sacs. *Sphaerosyllis erinaceus* carries its eggs attached to its dorsal surface between the neuropodia and dorsal cirri (1 to 4 eggs per segment on setigers 8 to 24). *Exogone naidina* carries its eggs attached to its ventral surface on about 7 to 14 segments (usually 4 per segment, but sometimes 1 to 3 per segment). In all four of these worms the eggs are retained until they hatch into young worms. *Potamilla neglecta* deposits its eggs on the inner surface of its tube, about one-third of the way down, and then secretes a thin, transparent membrane between itself and its eggs. *Spirorbis granulatus* incubates its eggs in a large brood pouch in the operculum, and *S. spirillum* incubates its eggs within its tube.

The leech *Crangonobdella murmanica* lays a large egg in a capsule that is attached singly to the host. The egg develops into a young worm before hatching.

The clam *Musculus corrugatus* lays large eggs within the byssal capsule with which it surrounds itself prior to spawning. The eggs remain inside the capsule until they develop into young clams. Although no individuals of *M. laevigatus* were found with eggs within their capsules of byssus threads, it is obvious that this clam also retains its eggs, for none of the younger specimens were within a net, or capsule, whereas individuals 20 mm. or more in length that were surrounded by such a byssal net were not uncommon.

It also appears probable that the clam *Cardita crassidens* has some arrangement for caring for its eggs, probably retaining them within the mantle cavity until young clams are formed, for unusually large

eggs—from 753 to 761 microns in diameter—were found in several individuals. These eggs were largely yolk.

Brooding of eggs was practiced by the tunicates also. On October 6, 1949, a specimen of *Dendrodoa grossularia* was found in which the atrial cavity was filled with eggs of a large size.

The production of large eggs by Arctic marine invertebrates is essential to brooding, for if the embryo is to develop to the crawling or other advanced stage before hatching, it must be supplied with a large yolk for growth.

Among the most surprising of these large eggs were those of the echiuroid worm *Hamingia arctica,* which were 900 microns in diameter and which perhaps accounted for the unusually large trochophore larvae that were occasionally found in the plankton.

Although the eggs of *Eukrohnia hamata* were not seen, they must, in order to produce embryos that were 3 mm. in length, have been large for a chaetognath. The same deduction can be made for the eggs of the leech mentioned above.

Several of the polychaete worms produce large yolky eggs, e. g., *Autolytus fallax. A. alexandri, Sphaerosyllis erinaceus, Exogone naidina, Eusyllis blomstrandi, Capitella capitata, Nicolea venustula, Lanassa venusta, Polycirrus medusa,* and *Potamilla neglecta.*

Many of the amphipods have exceptionally large eggs for the size of the animal. For instance, females of *Unciola leucopis* only 12.5 to 14 mm. in length produce eggs that are 0.7 mm. in diameter and from which emerge larvae 2.7 mm. in length; and *Photis reinhardti,* with females from 4.5 to 5 mm. in length, has eggs 0.5 mm. in diameter. In *Ischyrocerus commensalis* one female 3 mm. long was carrying 3 eggs 0.3 mm. in diameter, and another 5 mm. long was carrying 15 eggs that were nearly 0.5 mm. in diameter; in *Eurystheus melanops* females from 3.5 to 8 mm. long were carrying from 3 to 10 eggs from 0.4 to 0.5 mm. in diameter.

The eggs of the clam *Musculus corrugatus* measuring about 500 microns in diameter, and of the clam *Cardita crassidens* measuring from 753 to 761 microns in diameter, have been mentioned above.

In the gastropods large embryos may result from the production of large eggs or from the production of a large number of small eggs in which only a few hatch into embryos that feed on the undeveloped eggs. In still other instances eggs are provided with a nutritive substance similar to egg white upon which the developing embryos feed. Some of the species produce large eggs that are retained, probably within the pallial cavity, until the embryos are in the crawling

stage. By any of these methods the end result is large embryos. Snail embryos from 3 to 15 mm. in height are not uncommon.

The tunicate *Dendrodoa grossularia* produces eggs that are 0.25 mm. in diameter.

Although many of the marine invertebrates lay eggs at the beginning of summer, preparation for egg laying at this time must take place during the winter. Such preparation consists in the development of functional eggs and sperm. And this in turn must be preceded, in many instances at least, by the storage of oil during the summer for use in the production of eggs during the winter (see *Eualus gaimardi* under "Storage of Oil").

As soon as the ice goes out there are snail egg capsules in abundance. These must have been deposited during spring. The only other alternative is that they were deposited in the fall and development was slow or delayed until spring.

Although most of the egg capsules could be identified as to genus, only a few of them could be assigned to their proper species. In several instances in which the species could be recognized, it was noted that capsules with well-advanced embryos were present as soon as the ice went out and that freshly deposited capsules appeared throughout the summer and as late as the middle or end of October. It is possible that those capsules that were deposited in October were the ones containing well-advanced embryos late in July or early in August. Whether the same individual snail lays eggs more than once a year was not determined. It is possible that a snail that lays eggs in October could lay again in June or July provided that during the summer, at the same time it was producing eggs to be laid in October, it could also be storing oil to be used during the winter for producing eggs to be laid in June or July, or that it could find sufficient food during winter to produce eggs. But it seems improbable that any one snail reproduces more than once a year. From the slowness with which gonadal development took place in certain species that could be watched (the shrimp *Eualus gaimardi,* for instance) it seems doubly improbable that many species of the higher invertebrates, at least, could be capable of reproducing more than once a year.

Throughout the winter of 1949-50 the larvae of the pteropod *Clione limacina* were always present in plankton tows. During the entire winter there was no perceptible increase in size of these larvae, but in June larger larvae appeared, and on July 20 larvae 7 mm. long and adults 30 mm. long were taken. The 7-mm. larvae were still using cilia, for the wings were not sufficiently developed for locomotion.

In some of the pelagic invertebrates, such as jellyfishes, cteno-

phores, and chaetognaths, there are undoubtedly several generations a year, although the same individuals probably do not reproduce more than once. In all three of these groups both larval forms and adults, with all intermediate stages, were often present at one time.

Both budding and sexually mature hydromedusae were found throughout the summer months. Plankton tows during winter were not extensive enough for obtaining information on the development and reproduction of these forms during that season.

The jellyfish *Chrysaora* sp. contained eggs and swimming larvae on November 19, 1949. The commonest sea anemone (*Stomphia coccinea*) of the region was filled with large eggs on October 14, 1949. Would these develop into swimming larvae during the winter or would they be retained within the sea anemone until spring before becoming swimming larvae?

A large percentage of the bryozoans collected during February contained eggs. It is probable that these eggs were produced from food stored during summer and that the larvae would be released at the beginning of the open season.

The development of one species of polychaete worm was followed sufficiently to give information on how long the eggs are carried inside the body. The syllid *Autolytus fallax* Malmgren was found with large eggs inside the body on October 11, 1949. On January 25, 1950, a few specimens were found carrying egg sacs in which there were developing embryos, and on March 29, 1950, and April 7, 1950, there were hundreds of these worms swimming around with their egg sacs. The egg sacs from individual worms contained eggs and embryos in varying stages of development. Thus from the time large eggs were seen within the bodies of *Autolytus fallax* to the time when the majority of these worms were carrying sacs containing eggs, or developing embryos, a period of 5 to 6 months had elapsed.

Data on related forms are given in table 4.

Female stolons of the related *Autolytus prismaticus* were found on August 6 and 30, 1948, with eggs massed inside their bodies. A female stolon of *Autolytus alexandri* with swimming setae and with the body filled with eggs was dredged on February 18, 1950. Females of *Cirratulus cirratus* with eggs inside their bodies were found from the first week in August until the first week in September. A male of the sabellarid *Idanthyrsus armatus* Kinberg spawned August 9, 1949. The terebellid *Terebellides stroemi* M. Sars had ripe eggs and sperm on September 26, 1949, and *Potamilla neglecta* M. Sars was found incubating eggs on September 6, 1949. The terebellid *Thelepus cincinnatus* (Fabr.) had ripe eggs and sperm on October 11, 1949.

Developing worms were found in the egg capsules of the leech *Crangonobdella murmanica* Selensky on October 11, 1949. Would these emerge during the winter or would they remain in the capsules and emerge about the beginning of the open season? Three species of cumaceans were found with eggs in the marsupiums in September and October, and a number of amphipods were ovigerous during the winter (see table 4 for data). Numerous amphipods, certain isopods, and the mysid *Mysis oculata* were carrying freshly deposited eggs about the middle of October or later.

The fact that the clam *Cardita crassidens* had large eggs within its dorsal mantle cavity on October 11, 1949, suggests that this clam broods its eggs during the winter and releases young clams at the beginning of the open season or before. That the tunicate *Dendrodoa grossularia,* which was found filled with large eggs on October 6, 1949, also broods its eggs during the winter and releases large larvae at the beginning of the open season is also a possibility.

Data obtained on the eggs and breeding seasons of the animals are included in the discussion of the various groups of animals beginning on page 115. However, the principal information there presented is summarized in table 4, below. In some instances too few animals of a species were taken to provide information on the breeding season. In other instances the impossibility of identifying the animals prevented the keeping of records. When all the animals collected are identified, future workers will be enabled to keep more complete records on habits and breeding seasons.

TABLE 4.—*Data on eggs and breeding seasons*

Animal	Date	Remarks
Coelenterates:		
Hydroids		
Hydractinia sp.	8-10-48	Gonophores present
Corymorpha sp.	7-21-48	" "
Garveia sp.	10- 6-49	" "
Sertularella sp. ?	9- 6-48	" "
Sertularia sp.	10- 6-49	" "
	10-14-49	" "
Thuiaria elegans	8- 9-49	" "
	8-30-49	" "
T. lonchitis ?	8-21-48 to	" "
	9-15-48	" " (not so plentiful)
Hydromedusae		
Bougainvillea superciliaris	7-23-50	Appeared to be sexually mature
Rathkea octopunctata	8- 6-48	Budding
	7-13-50	"

TABLE 4.—*Data on eggs and breeding seasons*—continued

Animal	Date	Remarks
Coelenterates—continued		
Hydromedusae—continued		
Obelia sp., medusa	8- 6-48	Spawned eggs
Aglantha digitale	8- 6-48	Mature gonads
Scyphomedusae		
Cyanea capillata	8- 2-48	Ephyra stage
	8-16-48	" "
	9-30-49	" "
	10-17-49	Postephyra stage
	11- 4-49	" "
Chrysaora sp.	11-19-49	Eggs and larvae
Anthozoans		
Stomphia coccinea (sea anemone)	10-14-49	Many large eggs (697 microns) visible through body wall
Nemerteans:		
Amphiporus lactifloreus	9- 9-48	Large eggs within body
Echiuroids:		
Hamingia arctica	8-10-50	With large eggs (900 microns)
Chaetognaths:		
Sagitta elegans	July	Gonads immature (possibly others with mature gonads)
Eukrohnia hamata	9-27-48	Brooding young
Brachiopods:		
Diestothyris spitzbergensis	2-18-50	9 with eggs (195-227 microns), 1 with sperm
Bryozoans:		
Eucratea loricata	8- 6-48	With eggs
Carbasea carbasea	10- 6-49	With active sperm
Tricellaria erecta	10- 6-49	" " "
	2-18-50	With brown bodies
	8- 5-50	" " "
Dendrobeania murrayana	10-14-49	Full ooecia
	10-14-49	With brown bodies
Costazia ventricosa	8-17-49	With eggs
	10-11-49	Ovicells present
Alcyonidium polyoum	10-14-49	Eggs 112 microns in diameter
	2-14-50	Ovicells present
Crisia cribraria	8-10-48	With eggs
Annelids:		
Polychaetes		
Melaenis lovéni	10- 4-49	Developing eggs
Castalia aphroditoides	4- 7-50	Apparently mature eggs inside body

TABLE 4.—*Data on eggs and breeding seasons*—continued

Animal	Date	Remarks
Annelids—continued		
Polychaetes—continued		
Autolytus fallax	10-11-49	Eggs inside body
	1-25-50	Egg sac with developing embryos
	3-29-50	Hundreds with egg sacs
	4- 7-50	" " " "
	4-15-50	Many with egg sacs
	5-17-50	Several with egg sacs
A. alexandri	2-18-50	Female stolon with swimming setae, and body filled with eggs
A. prismaticus	8- 6-48	Female stolon with eggs massed inside body
	8-30-48	Female stolon with eggs massed inside body
Polydora caulleryi ?	8- 2-48	Larva in plankton
Sphaerosyllis erinaceus	9- 9-48	Eggs fastened to dorsal surface
	10- 6-49	Developing larvae fastened to dorsal surface (swimming setae visible in larvae)
Syllis fasciata	3-29-50	2 male stolons
S. cornuta	2-14-50	2 epitokes
	2-18-50	1 epitoke
	3-29-50	10 epitokes with eggs inside body
	4-15-50	2 epitokes with eggs inside body
Cirratulus cirratus	8- 6-48	2 with eggs inside body, 1 male with apparently mature sperm
	8-10-48	1 with apparently ripe eggs inside body
	9- 2-48	1 with apparently ripe eggs inside body
Idanthyrsus armatus	8- 9-49	1 male spawned
Lanassa venusta	8- 5-50	Large yolky eggs inside body
Nicolea venustula	8-21-48	Large yolky eggs inside body
	9-15-48	Large yolky eggs inside body
	8- 8-49	Large yolky eggs inside body
Thelepus cincinnatus	10-11-49	Ripe eggs and sperm
Polycirrus medusa	9-15-48	Large, reddish, yolky eggs inside body

TABLE 4.—*Data on eggs and breeding seasons*—continued

Animal	Date	Remarks
Annelids—continued		
Polychaetes—continued		
Polycirrus medusa—continued		
	10-11-49	Large, reddish, yolky eggs inside body
Terebellides stroemi	9-26-49	Ripe eggs and sperm
Potamilla neglecta	9- 6-49	Large, yellow, yolky eggs incubating in tube
Spirorbis granulatus	8-17-49	Eggs incubating in operculum
	2-18-50	Eggs incubating in operculum
S. spirillum	9- 9-48	Eggs incubating in tube
	8-30-49	" " " "
Leeches		
Crangonobdella murmanica	9-12-49	Developing worms in egg capsules
	10-11-49	Developing worms in egg capsules
Echinoderms:		
Ophiurans		
Gorgonocephalus stimpsoni	8- 9-49	Spawned freely. Swimming larvae developed
Amphiura sundevalli	August	Probably late August or early September
Holothurians		
Myriotrochus rinki	8-10-50	Eggs looked mature
Crustaceans:		
Copepods		
Copepod from sponge	8- 6-50	50 percent of females ovigerous
	8- 1-50	50 percent of females ovigerous
Herpyllobius arcticus	August	With eggs
Cirripedes		
Balanus crenatus	8-30-49	Young sets (1-1.5 mm. in diameter)
	10- 6-49	Young sets (1-1.5 mm. in diameter)
Mysids		
Mysis oculata	10-31-49	2 ovigerous females
Cumaceans		
Leucon sp.	10- 6-49	1 female with eggs
Petalosarsia sp.	10-14-49	1 " " "
Diastylis bidentata	8- 8-49	1 " " marsupium
D. dalli	9-16-48	1 " " eggs
Isopods		
Idotaega entomon	8-19-48	3 with marsupiums

TABLE 4.—*Data on eggs and breeding seasons*—continued

Animal	Date	Remarks
Crustaceans—continued		
Isopods—continued		
Idotaega entomon—continued		
	9- 2-48	15 with marsupiums, 2 with eggs (early stages), 1 just lost brood
	7-20-49	1 with freshly deposited eggs, 2 with young embryos, 1 with young
	9- 8-49	1 with eggs (early stages)
	10- 2-49	1 with marsupium, 1 with eggs (early stages), 1 with embryos
	10-28-49	1 with freshly deposited eggs
	7-13-50	2 with young
I. sabini	8- 6-48	1 with young ready to be released
	8-10-48	3 with marsupiums
	9-26-49	1 just lost brood
	9-30-49	1 with freshly deposited eggs
Synidotea bicuspida	10-11-49	1 with young
Idarcturus murdochi	9- 9-48	1 with eggs
Phryxus abdominalis	10- 6-49	1 " "
Amphipods		
Hyperia medusarum	7-20-49	2 with eggs
	10- 5-49	Females with eggs
	3-20-50	1 with eggs
	7-19-50	5 " "
	7-21-50	13 with eggs; 72 with developing marsupiums; juveniles
Themisto libellula	9-12-49	Many females molting. Eggs visible through integument
Anonyx nugax	8- 8-49	1 with eggs
	9-22-49	Many freshly molted. Eggs visible through integument
Paronesimus barentsi	8-21-49	1 with young
	10- 5-49	1 with eggs (early stages)
Onisimus normani	9- 8-48	1 " "
O. affinis	8-17-49	1 just lost brood
	9-26-49	1 " " "
Orchomenella pinguis	1-27-50	1 with eggs (late stages)
Socarnes bidenticulatus	10-11-49	1 " " (medium early stages)
	10-14-49	1 with young embryos

TABLE 4.—*Data on eggs and breeding seasons*—continued

Animal	Date	Remarks
Crustaceans—continued		
Amphipods—continued		
Stegocephalus inflatus	8- 9-49	1 with eggs
Stegocephalopsis ampulla	9- 9-48	1 with marsupium
Ampelisca eschrictii	8-21-48	Ovaries full of eggs
A. birulai	10- 6-49	1 with eggs (early stages)
Byblis gaimardii	9- 9-48	3 with developing marsupiums, 3 with eggs, 1 just lost brood
	10-11-49	2 with eggs (medium stages)
	2-18-50	8 with full ovaries, 1 with eggs (early stages), 2 with embryos (early), 2 with embryos (late stages)
Haploops laevis	10- 6-49	2 with developing marsupiums
	2-14-50	1 with eggs
	2-18-50	1 just lost brood
Pontoporeia femorata	9-22-49	1 ready to lay eggs, 1 with eggs (early stages), 2 just lost brood
Acanthostepheia behringiensis	9- 8-48	1 with developing marsupium
	9-22-49	4 had just molted
Pleustes panoplus	3-10-50	1 with eggs
Sympleustes pulchellus	9- 9-48	3 " "
S. uncigera	9-15-48	9 with eggs, 1 just lost brood
Paramphithoë polyacantha	8- 6-48	Females with developing marsupiums
	8- 9-49	Females with developing marsupiums
	8- 1-50	Females with developing marsupiums
Atylus carinatus	8- 1-50	2 with young, 1 just lost brood
Eusirus cuspidatus	8-23-48	1 just losing brood
	9- 9-48	1 " " "
	8- 9-49	2 with eggs (very early stages)
	9- 6-49	1 with young ready to escape
	10- 6-49	1 with young ready to escape
	10-11-49	1 soft-shelled and ready to lay eggs

TABLE 4.—*Data on eggs and breeding seasons*—continued

Animal	Date	Remarks
Crustaceans—continued		
Amphipods—continued		
Eusirus cuspidatus—continued		
	10-11-49	7 with young ready to escape
	10-14-49	1 just lost brood
Rhachotropis aculeata	8-21-48	1 with fully developed marsupium
		1 with eggs (early stages)
	8-23-48	1 with eggs, 3 with fully developed marsupiums
	9- 9-48	1 with eggs (medium early)
	10- 6-49	1 " " " "
	7-27-50	1 just lost brood
Melita formosa	8-21-49	47 with developing ovaries (eggs immature)
		57 with developing marsupiums
		17 with eggs
Maera danae	9-15-48	1 pair mating, 1 with eggs
	9- 6-49	1 with eggs (very early stages)
	10-14-49	1 with eggs
	8- 1-50	1 " " (very early stages)
Gammarus locustus var. *setosus*	10- 4-49	2 just molted, 3 pairs mating, 1 with eggs
	7-27-50	1 with developing marsupium
Gammaracanthus loricatus	8- 6-48	1 with eggs
	9- 2-48	1 with young nearly ready to escape
	9- 8-48	1 with developing marsupium
	9-12-49	1 just lost brood
	10- 4-49	1 " " "
	8- 1-50	1 with eggs (early), 2 just losing brood
Photis reinhardi	8- 3-48	1 just lost brood
	9- 9-48	1 " " "
	10-11-49	8 with eggs or young or just lost brood
	2-18-50	2 with eggs (late stages)
Eurystheus melanops	8-23-48	1 " "
	8-30-48	2 " "
	9- 8-48	12 " " , 1 with embryos
	9- 6-49	8 with eggs or young
	10- 6-49	3 " "
	10-11-49	5 " " or young

TABLE 4.—*Data on eggs and breeding seasons*—continued

Animal	Date	Remarks
Crustaceans—continued		
Amphipods—continued		
Eurystheus melanops—continued		
	10-14-49	5 with eggs or just lost brood
Protomedeia fasciata	8-21-48	2 with eggs
	9- 8-48	Many with eggs (advanced embryos)
Ischyrocerus commensalis	8-23-48	3 with eggs
	9- 9-48	All females with eggs (7)
	9-15-48	" " " "
	8- 9-49	1 with eggs (early stages)
	8-30-49	1 " " (early to medium)
I. latipes	8-23-48	Females with eggs
	9- 9-48	" " "
	9-15-48	1 just lost brood
	8- 8-49	1 " " "
	10-14-49	1 " " " , 1 with developing marsupium
	2-18-50	1 just lost brood, 1 with developing marsupium
	3-17-50	1 just lost brood
	8- 1-50	6 with marsupiums
Ericthonius hunteri		Ovigerous females were taken from the first of August to the middle of October
	10-14-49	2 with developing marsupiums
		5 with eggs (early), 1 with young
	2-18-50	3 with developing marsupiums, 3 with empty marsupiums, 1 with eggs (early), 1 with eggs (late), 1 with young leaving, 1 with embryos (medium)
E. tolli	9- 9-48	Ovigerous females
	10-11-49	" "
Unciola leucopis	8-17-49	1 with eggs
	9- 6-49	1 " "
	10- 6-49	1 with young, 1 with young just leaving
Dulichia spinosissima	9-10-50	1 with eggs (very early stages)
D. porrecta	3- 9 48	2 with eggs (early stages)

TABLE 4.—*Data on eggs and breeding seasons*—continued

Animal	Date	Remarks
Crustaceans—continued		
Decapods		
Pandalus goniurus	9- 9-48	1 with eggs
Spirontocaris arcuata	9-15-48	1 " "
S. phippsi	10-14-49	1 " "
S. spina	9- 9-48	1 " "
	8- 9-49	1 " " (embryos, very early)
Eualus gaimardi	8- 9-49	6 with eggs (pre-eye)
	8-17-49	1 " " (" ")
	9- 6-49	14 " " (" "); 4 (later stage)
	10- 6-49	1 with eggs (with eyes); 2 juveniles
	10- 6-49	5 with eggs (pre-eye); 1 (with eyes); 1 just lost brood
	10-14-49	14 (pre-eye); 17 (with eyes)
	7-22-50	1 soft-shelled female
	8- 1-50	15 (pre-eye); 1 with eggs ready to lay
E. fabricii	10-14-49	1 with eggs
E. suckleyi	9- 6-49	2 " " (early)
Lebbius polaris	9- 9-48	1 " "
Heptacarpus flexus	9- 9-48	1 " " (very early)
Sabinea septemcarinata	8- 9-49	1 " " (" ")
Argis lar	9- 8-48	1 " " (with eyes)
Sclerocrangon boreas	9-12-49	1 " "
	9-30-49	1 " "
Pagurus splendescens	8-21-48	4 " "
	8-23-48	2 " "
	9- 8-48	2 " " ; 2 just lost brood
	9-15-48	1 with eggs
	10- 5-49	1 " " (about 200, early)
P. trigonocheirus	8-23-48	1 with eggs (early)
	9- 2-48	2 " " (")
	9- 8-48	1 " " (")
	9- 9-48	1 " " ("); 2 with empty egg cases; 14 juveniles
	8-17-49	1 with eggs (early)
	9- 6-49	1 " " (")
	10- 6-49	2 " " ("); 1 with eye spots
	10-11-49	1 with eggs (early)
	8- 1-50	1 " " (very early)

TABLE 4.—*Data on eggs and breeding seasons*—continued

Animal	Date	Remarks
Crustaceans—continued		
Decapods—continued		
Hyas coarctatus alutaceus	8-21-48	Several with eggs, 1 soft-shelled
	8-23-48	1 with eggs (early); 1 (advanced)
	9- 9-48	3 with eggs (early); 1 ready to lay; 1 soft-shelled male, 1 soft-shelled female
	9-15-48	4 with eggs (early); 1 (advanced)
	8- 9-49	11 with eggs
	8-17-49	1 " " (early)
	10- 6-49	1 " " (with eyes)
	10-11-49	1 " " (very early)
	10-14-49	1 " " (early); 1 with eyes
	8- 1-50	1 with eggs (very early) 1 " " (early)
Paralithodes camtschatica	8-12-48	1 with empty egg cases
	9- 4-48	1 with eggs
Chionocetes opilio	8- 2-48	1 soft-shelled female
Arachnids:		
Pycnogonids		
Nymphon grossipes	9- 9-48	1 male carrying eggs
	8- 8-49	1 " " "
	9-26-49	2 males " "
	10- 2-49	1 male " "
N. brevirostre	9- 9-48	1 " " "
N. longitarse	9-12-49	1 " " "
	9-26-49	1 " " "
Pseudopallene circularis	9- 9-48	1 male carrying young just ready to escape
Mollusks:		
Pelecypods		
Musculus corrugatus	8-30-49	Embryonic clams within byssal net
Astarte montagui	10-11-49	Eggs 292 microns in diameter
	2-14-50	Eggs 282-288 microns in diameter
	2-18-50	Eggs 282-288 microns in diameter
Cardita crassidens	10-11-49	Several with eggs from 753-761 microns in diameter, mostly yolk

TABLE 4.—*Data on eggs and breeding seasons*—continued

Animal	Date	Remarks
Mollusks—continued		
Gastropods		
Clione limacina		Larvae throughout winter with no apparent growth until June
	7-20-50	Larvae (7 mm.) and adults (30 mm.)
Aldisa zetlandica ?	9- 8-48	Coiled rose-colored egg ribbon
Admete sp.	8-23-48	Egg capsules
	9- 6-49	" "
	10-16-49	" " with embryos with shells
Admete sp. No. 2	9- 9-48	Egg capsules
Volutopsius stefanssoni ?	10-21-49	Empty egg capsule
Jumala sp.	8- 6-48	Capsules with large embryonic snails ready to escape, others still with nurse eggs
	9- 9-48	Capsules with large embryonic snails ready to escape, others still with nurse eggs
	10-17-49	Freshly deposited capsule
Plicifusus sp.		Capsules from Aug. 1 to Oct. 14
	10-14-49	Capsules with recently laid eggs
		Capsules with young embryos
		Capsules with 5-9 young snails
Neptunea sp.		Capsules from July to October
Buccinum sp. (9 or 10 sp.)		Capsules of different types from the time the ice went out until Oct. 16
	10- 3-49	Type 1. Mass of capsules with empty capsules and others containing eggs
	10-16-49	Type 2. 3-5 embryos (1.8 to 4 mm.) per capsule still feeding on nurse eggs
	9-28-49	Type 3. Capsules with eggs
	10-16-49	Type 4. 10-12 embryos without shells

TABLE 4.—*Data on eggs and breeding seasons*—continued

Animal	Date	Remarks
Mollusks—continued		
Gastropods—continued		
Buccinum—continued		
	10-16-49	Other capsules with eggs only
		Other capsules with 4-5 larger embryos with nurse eggs
		One capsule with 14 embryos in earlier stage
		Capsules with 15-17 embryos with eye spots
Boreotrophon sp.	8-30-48	2 capsules, each with 2 embryos
Trichotropis bicarinata ?	9- 1-49	3 capsules, with 13, 14, and 24 embryos, respectively
Natica clausa		First of open season until last of October egg rings present
	10-11-49	One egg ring had young snail in each egg space
Polinices sp.		Egg rings present from first dredge hauls until end of October
	8-21-49	Some egg rings with eggs, others with embryos
	10-28-49	Recently deposited egg rings
Margarites costalis ?		Egg masses on the bryozoan *Alcyonidium disciforme* throughout entire season
M. frigidus	8-17-49	Large eggs (0.4 mm.) in ovaries
M. vahli	8-17-49	Ovaries with fairly well-developed eggs
Tunicates:		
Dendrodoa grossularia	10- 6-49	Atrial cavity filled with eggs (0.25 mm. in diameter)
Molgula griffithsi	8- 1-50	Eggs appeared ripe
Molgula sp.	8-30-49	Eggs with larvae showing "tadpole" tail

The records for some of the above animals are too isolated to be of much value in themselves, but by adding these to the records of future investigators, it will be possible eventually to compile sufficient data

to present the entire picture of the breeding habits and breeding seasons of these Arctic invertebrates.

METHODS OF COLLECTING AND PRESERVING SPECIMENS

DREDGING, SUMMER, 1948 AND 1949

Since the beach and subbeach region at Point Barrow is of gravel and there are no rocks for the attachment of animals, and as the ocean freezes over and ice grounds out to a depth of 90 to 100 feet, there is no such thing as tidal fauna, so conspicuous in many beach areas. The majority of invertebrate animal life along shore occurs 100 feet or more beneath the surface of the water. Dredging had to be employed almost exclusively for exploring the bottom, although a certain amount of trapping was done through the ice (see "Trapping Through the Ice"), and some grab sampling was undertaken.

Even in summer, dredging at Point Barrow is not so simple as in many regions. There is no harbor and no pier or dock, and it is not possible to leave the boat anchored offshore. Consequently, each time the boat was used it was necessary to push it into the water and pull it ashore again. This was done with a caterpillar tractor lent by the Arctic Contractors. The dates on which dredging activities began and ceased were dependent on the time the ice went out in the summer and the time the gravel of the beach froze, for after the gravel was solidly frozen the boat could not be hauled ashore without injuring the bottom. Dredging was therefore usually limited to a period beginning not earlier than the last week in July and ending early in October. Hand dredging from a skiff may be possible in the second or third week of July. More of the problems of dredging in the Arctic are mentioned under "Currents."

A large waterproof canvas was placed on the 10-by-14-foot working space on deck and the contents of the dredge were emptied onto it (pl. 3, fig. 2; pl. 4, fig. 1). The material was given a preliminary sorting in order to rescue the more delicate and perishable animals, which were placed in jars or pails of ocean water. During October 1949, many of the dredged animals froze on the deck before they could be taken to the laboratory.

DREDGING, WINTER, 1949-50

The Danes devised a method (see Thorson, 1946a) of dredging through the ice by lowering a dredge to the bottom before freeze-up.

Two lengths of coir rope (selected because of its resistance to a long stay in the water) were attached to the dredge and extended loosely along the bottom in opposite directions, with the dredge at an angle of 180° to the ocean bottom. A small anchor was attached to keep the rope taut from the bottom to the surface. Buoys were placed at the surface and each buoy was connected to the vertical portion of the rope by means of a solid wire about 15 feet in length. When the sea froze over, a hole was made around each buoy and a dredge haul could be made by drawing the dredge back and forth between the holes. A locality had to be selected where the ice would not break.

This last requisite precludes the use of the above method of winter dredging at Point Barrow. There is no location where the ice does not break. It may break up several times before the final freeze-up, and sometimes great ridges are piled up and carried ashore (pl. 8, fig. 1). It was therefore necessary to originate a method that could be carried out after freeze-over occurred.

At first a few dredge hauls were tried between holes in the ice about 30 feet apart. Then holes were made at greater intervals with the ice-cutting device (pl. 2, fig. 2) so that a line could be threaded between them. But a distance of even 100 feet between the two most distant holes was insufficient to allow enough horizontal drag on the dredge, with the result that very little animal life was obtained. It was also necessary to select a location that could be reached by a weasel in order to haul the ice-cutting machinery to the site. This precluded dredging more than 2 miles from shore by this method.

Unsuccessful attempts were made to use a prairie ice jigger or creeper such as is used by Canadian fishermen to carry a line under the ice of lakes. Also valuable time was lost trying to perfect a creeper that would work under ocean ice, the underside of which is covered with a slush 3 or 4 inches thick that piles up ahead of the creeper and makes the ice uneven.

The only recourse was to select a location in a lead that had recently frozen over so that the ice was thick enough to support workers and equipment but thin enough to make the digging of holes by hand not too laborious or time-consuming. Two large holes were made 300 feet or more apart. (See fig. 3, *a* and *b*.) A crew of three Eskimos was employed to thread a line between these holes. One (fig. 3, 5) held the line, another (7) dug holes on a slant at 15 feet apart, and the third (6) grappled the line by means of a pole with a hook on the end. The end of the line extending under the ice from *a* to *b* was attached to the dredge line (9) at *a* and drawn through to *b*. The dredge was then lowered straight down to the bottom through

a. A team of seven dogs was hitched to the slack dredge line at *b*, then driven ahead, drawing the dredge along the bottom and finally up to the opening at *b*, where the specimens collected were taken out and transferred to 5-gallon thermos jars. This transfer had to be made quickly to prevent the animals from freezing solid in the open air, the temperature of which was usually −25° to −30° F. The tent (*4*) with a stove was necessary to warm the hands occasionally to pre-

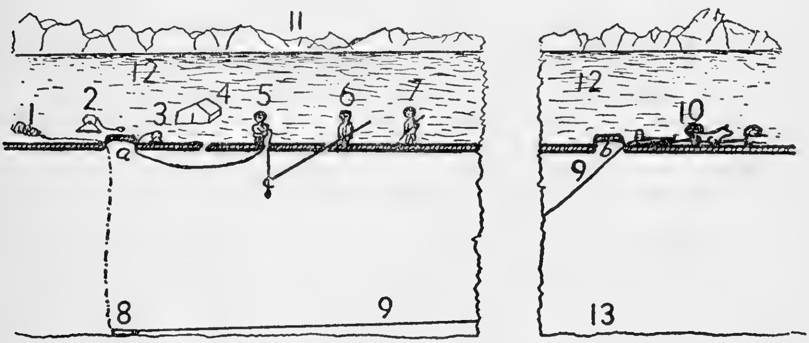


FIG. 3.—Dredging by dog team. 1, Backhaul line releasing dredge in case of fouling. 2, Dredge line and reel. 3, Cod line and reel. 4, Tent with stove for making coffee and warming hands. 5, Eskimo dropping weight for next Eskimo (6) to hook. 7, Eskimo digging hole. 8, Dredge dropped ready for towing. 9, Dredge line. 10, Dog sled and nine dogs. 11, Old ice. 12, New ice 4 or more inches thick, depending on age. 13, Ocean bottom. *a* and *b*, Large holes 345 feet apart; missing portion represents 240 feet.

vent them from freezing. After the dredge was emptied it was hauled back from *b* to *a* by means of the stern line (*1*), and the procedure was then repeated. In making each haul an attempt was made to swing the dredge sufficiently far to one side or the other to prevent its dragging along a previous course.

This was a laborious method but it accomplished the purpose. Much time was consumed by the trip out to a suitable site and the return trip to the laboratory. Travel in the Arctic at 30° below zero is invigorating, but working with gear and marine animals at such a temperature while the hands are wet with ocean water is extremely difficult and even painful. Some of the gear could be hauled by dog team; the remainder had to be carried. The dog team was hired from Eskimos in the village of Barrow, and arrangements had to be made the preceding day to have the team at the laboratory the morning of the day the dredging was to be done. Despite the difficulty of this method of collecting, good results were obtained, as can be seen from the list of animals collected on February 18, 1950, at a depth of 162 feet, 3.2 miles from shore.

In preparation for winter dredging, several good places over rubble bottom with rich fauna had been located by triangulation during the summer of 1949. However, storms during October of that year carried great quantities of mud containing vast amounts of tundra vegetation and debris from Elson Lagoon into the ocean, and large quantities of mud from the mud-zone bottom were stirred up and carried out to sea. This finer material was still floating when the ocean froze over, causing the top 8 inches of ice to be muddy. By the time the ice was 8 inches thick, this fine mud had settled below the freezing point and was deposited to a depth of 3 or 4 inches over the bottom, covering many of the animals. Instead of a rich rubble-bottom fauna there was obtained a mixture of those animals that had not been completely covered by the mud, or that had come to the surface, and a few that had been carried from their normal mud-zone habitat and had become established in the mud layer over the rubble. No doubt quantities of sessile rubble-zone animals were smothered by the mud. Under normal circumstances rubble bottom could have been found at depths of 125 feet and, in certain places, even at 110 feet.

Dredging through the ice during the winter of 1948-49 would have yielded a hundred times more marine fauna than did the operation in 1949-50, and probably much more information regarding the winter activities of the animals, but knowledge of the vicissitudes of life to which these arctic animals are subjected would not have been obtained.

This is another example of the necessity for several years of continuous work on any ecological survey, which the writer has always advocated. It is hoped that someone will be able to do sufficient dredging to determine how long the mud covering lasts and how much time is required for the animals to reestablish themselves.

BOTTOM SAMPLING, WINTER, 1949-50

Innumerable samplings were taken through the ice by means of grabs in order to get some idea of the extent of the mud covering and in the hope of finding a spot that was not so covered. Several miles of coast were explored in this manner to a distance of 4.5 miles from shore, but no area was found free from the blanketing mud. Dredging and sampling were extended to a depth of 185 feet, but the conditions there were no better, and it was impossible to try greater depths because the ice did not extend out far enough.

Two sizes of grabs, neither of which brought up a very large sample, were used. The smaller brought up about a third of a cupful of

material and the larger a cupful or more. Sampling could be done only where the ice was thin after the freezing over of a lead. As winter progressed and such places formed farther and farther at sea, searching began about 3 miles from shore. The farthest winter station on the ice was 4.5 miles from shore. After a suitable lead was located it could not be used more than two to four days before the ice became too thick to make holes through it for the grabs.

Holes were made by hand with an ice-boring tool or an Eskimo-type narrow-bladed tool. The very efficient ice cutter (pl. 2, fig. 2) developed by John Huff, the mechanic at the laboratory, could be used only nearer shore in places that could be reached by a weasel, which was used to haul the ice cutter and furnish power to run it. A weasel could not be driven over thin ice, and it could not go over or around certain ice ridges. Consequently, sampling locations had to be reached on foot, for the inconvenience of securing a dog team ruled out that form of transportation. Heavy clothing, ice-digging gear, sounding gear, thermos jars, and a rifle made traveling difficult. Thermos jugs were essential for taking the collected animals to the laboratory without freezing. The grab with its contained material could not be left in the water near the surface more than a few moments without freezing, for the water temperature averaged about $-1.5°$ C.

Had the layer of mud not been deposited over the rubble zone, grab sampling would have yielded more animals and more data concerning them. As it was, such sampling made possible a survey of several miles of shoreline out to 4.5 miles from shore and established the fact that mud had been deposited over the entire rubble bottom in this area.

DREDGING, SUMMER, 1950

Because of the deposition of mud mentioned above, dredging operations in the summer of 1950 were unsatisfactory. These activities showed that the mud gradually became thinner until at 20 miles from shore only a thin layer was encountered. Since this distance was considered the limit of safety with the *Ivik* (pl. 3, fig. 1), even under the most favorable weather conditions there was little opportunity to dredge except where a thick layer of mud still blanketed the normal fauna. Hours were required to work through a haul of this sticky mud, and the proceeds were disappointing.

PLANKTON SAMPLING, SUMMER

During the summer of 1948 plankton hauls were made from a skiff propelled by rowing, or from a grounded ice floe. During the summers of 1949 and 1950 plankton tows were taken from a skiff, but launching a skiff was not always feasible or practicable, as the surf was often too heavy. Consequently, tows had to be made when conditions were favorable rather than at stated intervals or at the most desirable times. Sometimes ice floes were grounded in such a manner that by walking to the outer edge and throwing a plankton net as far as possible satisfactory plankton samples could be obtained.

Occasionally samples could be taken on calm days by casting a net from the shore, but this method was not satisfactory because the gradual slope of the bottom made it almost impossible to get the net into water of sufficient depth.

PLANKTON SAMPLING, WINTER

After the ocean froze over, plankton samples were taken through holes in the ice. Several stations were maintained throughout the winter at various distances from shore (see "Trapping Through the Ice"), but the one most frequently used was over 80 feet of water at 1.6 miles from shore. This station was used from January to the first part of July 1950, inclusive. Holes farther from shore were destroyed by the movement of ice and in some instances could not be used more than a few weeks.

In order to make the sampling as uniform as possible and thus obtain information on the relative quantitative changes taking place in the winter months, a definite procedure was followed. First, if the hole had frozen over, the ice had to be broken and removed with a large sieve-dipper; or if not completely frozen over there was always slush ice to be dipped out. A plankton net with a flask attached was then lowered to the bottom and towed vertically to the surface. This was done three times. When the flask was brought up it had to be thickly wrapped in insulating material for transportation to the laboratory.

There was also the problem of preventing the net from freezing solid as soon as it became wet, thus closing the meshes so that the water would not drain out. The only satisfactory method of preventing this was to pour into the hole a pailful of hot water, which warmed the surface water sufficiently to keep the net from freezing when lowered, and another pailful just before the net was withdrawn. A stove for heating the water was housed in a snow house (pl. 4,

fig. 2) which not only protected the flame of the stove from the wind, but also provided shelter for the workers.

The advent of late spring brought another problem—dilution of the ocean water with the fresh water from the melting ice. With several feet of fresh water floating on top of the salt water, practically all the planktonic animals were killed when the net was drawn to the surface. In an attempt to overcome the lethal effects of the fresh water, a water-sample bottle was lowered by means of a long pole to a depth of 10 feet and the salt water thus obtained was poured into the flask at the end of the plankton net before the latter was lowered. The heavier water in the flask prevented the fresh water from entering, so that the majority of the planktonic forms could be brought to the surface alive. The dead ones, mostly chaetognaths, were probably those that had ventured into the upper layer of water and were already dead when taken in the net.

CARING FOR ANIMALS IN THE LABORATORY

As mentioned above, dredged material was partially sorted on the deck of the boat (pl. 4, fig. 1). The material was then carried to the laboratory, where it was carefully separated. Because of the higher temperature and the absence of running salt water, the specimens could not be kept alive in the laboratory for any great length of time. They were sorted into pans and large and small finger bowls and placed in an unheated anteroom until they could receive further attention. Toward the end of the dredging season the anteroom would become too cold, especially at night, and the containers were placed on the floor near a door inside the laboratory room. A thin coating of ice over the pan or bowl was not fatal to the animals.

In 1949 a kerosene-operated refrigerator was available. It formed an excellent storage place for specimens—when it worked. Unfortunately, it could not be relied upon, and during the night it might become fatally warm, or it might freeze solid the contents of pans and bowls. A walk-in refrigerator that became available for use later in 1949 made it possible to keep some of the animals for several weeks, thus allowing more time for anesthetization and preservation and for examination of living animals.

When time permitted, colored 2-by-2-inch slides were made of the live specimens and later sent to the taxonomists working with the subjects. Taxonomists seldom see living specimens of the animals with which they work, and consequently have no idea of their color or appearance before they are preserved.

Also, when possible, some of the animals were examined in an attempt to determine their breeding season from the state of development of the gonads. It was not feasible to try to fertilize the eggs as they were all too often cooked or frozen, depending on the vagaries of the refrigerator.

Plankton samples were also kept in the refrigerator and, later, in the reefer (a walk-in refrigerator), which prolonged the life of the specimens, thereby allowing more time to work on them.

DREDGING STATIONS AND COLLECTING DATA

ZONATION

In general there are three types of bottom off Point Barrow. From the shore out to a depth of 10 to 20 feet there is gravel, which is continuous with the beach; 20 to about 100 feet, fine, blue, compact, sticky mud; and beyond 100 feet, rubble, in which there may be streaks of boulders, gravel (coarser than the beach gravel), or shell (mainly *Hiatella*), and regions in which there are mixtures of some or all of these. In general, the farther one proceeds oceanward, the less likelihood there is of boulder streaks, but there are stones of varying sizes everywhere.

For miles out to sea there is an annual deposition of mud, the amount depending on whether the ice stays near shore; when the ice is "in" there is less shore erosion because there is less surf. In 1948 the bottom was free of mud beyond a depth of 100 feet, but in October 1949 the entire ocean bottom offshore was covered with 3 or 4 inches of mud.

These three regions have their respective faunas. In the gravel along shore *Rhizomolgula globularis* occurred in patches where the sand had been segregated from the coarser gravel, and in places as many as 50 pounds of this tunicate could be brought up in a single dredge haul. Quantities of the washer-shaped bryozoan *Alcyonidium disciforme* were also taken all along the gravel zone. These two were by far the most abundant surface animals of this zone. An occasional white dorid, probably *Aldisa zetlandica,* and certain annelids, such as *Phyllodoce groenlandica,* were dredged.

The animals living within the mud at the shoreward edge of the mud zone encroached upon the gravel zone where the gravel was not so thick as to close the burrows or allow them to collapse. Comparatively little is known of the animals living beneath the surface in the mud zone, for sampling in that region is a tedious, time-consuming process, but good collections were made of the surface and near-

surface dwellers and those living on the shoreward border. The following is a list of the animals of this region in the order of their relative abundance:

Echiurus echiurus alaskanus (echiuroid worm)
Arenicola glacialis (polychaete—lugworm)
Myriotrochus rinki (sea cucumber)
Antinoë sarsi (polychaete)
Melaenis lovéni (polychaete)
Harmothoë imbricata (polychaete)
Hamingia arctica (echiuroid worm)
Halicryptus spinulosus (priapulid worm)
Burrowing anemones (2 species)
Burrowing tunicates (2 species)
Mya truncata, small (clam)
M. japonica, small (clam)

Living within the mud in the mud zone farther out, the following were found:

Cerianthus sp. (burrowing anemone)
Macoma calcarea (clam)
Astarte montagui (clam)
Myriotrochus rinki (burrowing sea cucumber)
Nucula tenuis (clam)
Musculus discors var. *laevigatus* (clam)
M. corrugatus (clam)
Nuculana sp. (clam)
Macoma oneilli (clam)

On the surface in the mud zone the following were common:

Foraminifers
Dulichia porrecta (amphipod)
Pagurus splendescens (hermit crab)
P. trigonocheirus (hermit crab)
Hyas coarctatus alutaceus (crab)
Serripes groenlandicus (clam)
Liocyma fluctuosa (clam)

Not strictly confined to the bottom was the ubiquitous amphipod *Apherusa glacialis,* which might be found on the undersides of ice cakes, among the gravel, or on the bottom.

The rubble zone varied greatly in different areas, depending on the size of the rubble and the amount of shell, gravel, and mud. In general, the farther from shore the more often patches of mud were encountered, perhaps because of the weaker currents in this area, at least along the bottom. Fauna was most abundant in those regions containing large boulders—a conservative estimate, based on the number of animals collected, would indicate about 1,154 tons per acre.

Occasionally large stones and boulders comparatively free of sessile animals, except juveniles, were brought up. This would indicate that these stones and boulders had recently been dropped out of the ice or had been rubbed by some deep floe, which killed the animals.

The predominant invertebrates in the rubble zone were bryozoans, sea anemones, sea cucumbers (*Psolus stimpsoni*), sea urchins (*Strongylocentrotus drobachiensis*), the octocoral *Eunephthya rubiformis,* and barnacles, all varying in abundance at the different stations. For lists of representative animals from stations in this zone, see below under stations 20, 37, 44, 46, and 47.

DREDGING STATIONS AND REPRESENTATIVE ANIMALS

Table 5.—*Dredging stations*

No.	Date	Depth in feet	Type of bottom and remarks
1	7-20-48	10	Gravel
1a	7-26-48	22	Mud
2	7-26-48	50	Mud
3	8- 2-48	30	Mud
4	8- 6-48	40	Stones, mud, gravel (Eluitkak Pass)
5	8- 9-48	10-20	Gravel (alongshore from base to village)
6	8-10-48	40	Stones, mud, gravel (Eluitkak Pass)
7	8-21-48	80	Gravel
8	8-21-48	100	Gravel, small stones
9	8-21-48	140	Small stones (up to 4 inches), gravel
10	8-23-48	150	Gravel, small stones
11	8-23-48	20	Mud
12	8-30-48	40	Eluitkak Pass
13	9- 2-48	40	Eluitkak Pass
14	9- 8-48	110	Incomplete haul; rough current and wind
15	9- 8-48	60	Mud (out from radio masts)
16	9- 8-48	15	Sandy (out from radio masts)
17	9- 9-48	80	Mud
18	9- 9-48	100	Mud
19	9- 9-48	110	Mud, gravel
20	9- 9-48	125	Stones (sea urchins, *Psolus,* sea anemones)
21	9-15-48	110	Stones, mud, gravel (*Psolus,* sea anemones)
22	9-15-48	120	Stones (*Psolus*)
23	9-15-48	130	Stones (sea anemones, *Psolus,* sea urchins)
24	9-16-48	110	Shells, pebbles, mud
25	8- 8-49	120	Gravel, stones (large), mud
26	8- 9-49	130	Stones, gravel
27	8- 9-49	420	Stones, gravel
28	8- 9-49	70	Mud
29	8-17-49	438	Stones
30-31	8-17-49	522	Stones (sea urchins)
32	8-17-49	741	Mud (worm tubes)

TABLE 5.—*Dredging stations*—continued

No.	Date	Depth in feet	Type of bottom and remarks
33	8-30-49	184	Stones, boulders (*Psolus* and sea urchins—many)
34	8-30-49	30	Mud
35	9- 1-49	328	Gravel (coarse), stones (few large)
36	9- 6-49	477	Rocks (few) (worm tubes)
37	9- 6-49	217	Stones, large perforated rocks
38	9- 8-49	246	Pebbles, gravel, mud
39	9- 8-49	148	Mud
40	9- 8-49	10	Gravel, mud (alongshore)
41	10- 6-49	295	Rocks, stone, gravel (*Psolus*)
42	10- 6-49	216	Rocks, stones (*Psolus* and sea urchins)
43	10- 6-49	213	Gravel, mud
44	10-11-49	453	Rocks, stones, gravel (small amount) (*Psolus*)
45	10-11-49	341	Rocks (few), stones, gravel (sea urchins)
46	10-14-49	152	Stones, mud, rocks (few)
47	10-14-49	175	Gravel, stones (small) (sea urchins)
48	2-13-50	129.5	Mud (bottom sampler)
49	2-14-50	149	Mud, stones (small) (haul made by dog team)
50	2-18-50	162	Mud, gravel, stones, rocks (few small) (haul made by dog team)
51	3- 9-50	135	Mud (very sticky) (haul made by dog team)
52	3-18-50	185	Mud, gravel, stones (bottom sampler)
53	3-21-50	120-130	Mud (small bottom sampler)
53a	4-11-50	170	Mud (bottom sampler) (off radio mast)
53b	4-11-50	175	Mud (bottom sampler) (off Browerville)
54	7-21-50	72	Mud
55	7-22-50	132	Mud, gravel, shell, stones
55a	7-22-50	134	Mud, gravel, shell, stones
56	7-22-50	141	Mud, gravel, shell, stones
57	8- 1-50	118	Mud, gravel, shell, stones
58	8- 1-50	122	Mud, gravel, shell, stones
59	8- 1-50	138	Mud, gravel, sand, shell, stones (few small)
60	8- 1-50	40	Mud, stones (Eluitkak Pass)
61	8- 5-50	204	Mud, stones, gravel
62	8- 5-50	151	Mud, gravel

In the following discussion the animals listed under each station were selected largely on the basis of their relative abundance. Unless it occurred at the station in such profusion as to be counted in multiples of ten an animal is not ordinarily listed. Occasionally a single animal is listed because of its special significance. Unfortunately, since the hydroids, sea anemones, and many of the bryozoans have not been identified, and the taxonomist did not correlate the

bryozoans named with depths and dates, data for these groups may not be representative.

STATION 1 was in the gravel zone. Special techniques employed here might yield more animals, especially small ones such as amphipods, which were frequently observed near shore crawling in and out of the gravel. The presence in this zone of an animal such as the dorid *Aldisa zetlandica* (?) is amazing. Since it was present as soon as the ice went out it could not have migrated from deeper water, and the only explanation for its existence here is that it burrows into the gravel. But it seems incredible that a single specimen could survive the grinding to which the gravel is subjected when the ice breaks up and piles up in ridges, as it does in the early winter.

Representative animals from a dredge haul from this station are as follows: Hydroids—*Corymorpha* sp., 2. Nemerteans—*Amphiporus lactifloreus,* 1; *A. macracanthus,* 1. Bryozoans—*Alcyonidium disciforme,* 10. Polychaetes—*Phyllodoce groenlandica,* 14. Amphipods—*Atylus carinatus,* 4. Gastropods—*Aldisa zetlandica,* 1; *Cylichna occulta,* 1.

STATION 1a was in the mud zone where it is difficult to obtain a true sampling because it is impossible to dredge to the depth at which most of the animals live. The following were among those obtained: Bryozoans—*Alcyonidium disciforme,* 16. Holothurians—*Myriotrochus rinki,* 9. Polychaetes—*Pectinaria granulata,* 8.

STATION 2 was in the typical mud zone and the most important animal in the hauls was *Hydractinia* sp. on snail shells.

STATION 3 was also in the typical mud zone. Nemerteans—*Amphiporus pacificus,* 1; *Lineus ruber,* 1; *Micrura alaskensis,* 1. Bryozoans—*Alcyonidium disciforme,* 13. Holothurians—*Psolus fabricii,* few (probably washed in from the rubble zone); *Myriotrochus rinki,* 15.

STATIONS 4, 6, 12, 13, and 60 were at Eluitkak Pass, where the depth is given on U. S. Coast and Geodetic Survey maps as 40 feet, but a sounding made in the summer of 1949 gave 46 feet. No doubt the depth varies somewhat, for a strong current sweeps through the Pass. The amount of mud found in a dredge haul is somewhat variable. At this depth one should expect to encounter a mud bottom, for in the open ocean no rubble bottom is found in less than 100 feet of water, but the current here keeps the mud washed away and the surface of the stones exposed so that animals may grow on them.

On the whole the fauna of Eluitkak Pass is like that of the rubble bottom in the open ocean at depths of 110 feet or more. One striking difference is the total absence of echinoderms, owing undoubtedly to

the dilution of the ocean water by the fresher water from Elson Lagoon. At Eluitkak Pass the octocoral *Eunephthya rubiformis* was especially abundant, and the flared-goblet-shaped sponge *Echinoclathria beringensis* was found in greater numbers and larger size than in any other locality.

Important animals from Eluitkak Pass: Sponges—*Cioxeamistia* sp., 2; *Halichondria lambei* (C).[2] Hydroids—*Hydractinia* sp., 2; *Clytia* sp., 6-10; *Obelia* sp., several; *Lafoeina maxima* (C-A). Anthozoans—*Eunephthya rubiformis* (AA); *Halcampa duo-decimcirrata* (?), 1; *Stomphia coccinea,* 4. Turbellarians—*Notoplana atomata* (A, 20 in one haul). Nemerteans—*Amphiporus lactifloreus,* 6. Priapulids—*Halicryptus spinulosus,* 1. Bryozoans—*Eucratea loricata* (C); *Carbasea carbasea* (A), perhaps more abundant here than at any other station; *Tegella armifera* (C); *Scrupocellaria scabra* var. *paenulata,* several; *Cystisella bicornis,* n. sp., few; *Crisia cribraria* (C); *Alcyonidium pedunculatum* (A). Polychaetes—*Harmothoë imbricata,* 25; *Castalia aphroditoides,* 12 (nearly one-half of the 28 specimens of this species collected came from three hauls from Eluitkak Pass); *Eusyllis blomstrandi,* 25; *Cirratulus cirratus,* 14. Copepods—*Herpyllobius arcticus,* 8; unidentified copepod from sponge *Echinoclathria beringensis* (A). Cirripedes—*Balanus crenatus* (AAA). Isopods—*Idotaega entomon* (A); *I. sabini* (A). Amphipods—*Acanthostepheia behringiensis,* 3; *Paramphithoë polyacantha,* 4; *Atylus carinatus,* 19 (the only place this species was taken except for four at 10 feet and one that washed ashore); *Gammarus locustus* var. *setosus,* 4; *Gammaracanthus loricatus,* 6; *Ischyrocerus latipes,* 21. Decapods—*Pagurus splendescens,* 4; *P. trigonocheirus,* 8. Pelecypods—*Musculus niger,* 2; *Astarte borealis,* 16; *Hiatella arctica* (AAA). Gastropods—*Neptunea* sp., 5; *Buccinum angulosum,* 6. Tunicates—*Molgula griffithsi* (AA).

STATION 5, in the gravel zone, yielded very little animal life: Hydroids—*Obelia* sp., 1 col. Echiuroids—*Echiurus echiurus alaskanus,* tail end of one specimen. Bryozoans—*Alcyonidium disciforme,* 1. Amphipods—*Weyprechtia heuglini,* 3. Isopods—*Idotaega entomon,* 1 (1.5 inches). Fishes—*Limanda aspera,* 1 (1.5 inches).

STATION 7 was evidently where a tongue of gravel extended into the mud zone from the rubble zone. Animals: Bryozoans—*Rhamphostomella gigantea,* n. sp., 1 large. Amphipods—*Protomedeia fasciata,* 3; *Dulichia porrecta,* 9. Decapods—*Pagurus splendescens,* 14;

[2] In this discussion (C) = common, (A) = abundant, (AA) = very abundant, (AAA) = exceedingly abundant, (R) = rare, and col. = colony or colonies.

P. trigonocheirus, 11; *Hyas coarctatus alutaceus,* 4. Pelecypods—*Serripes groenlandicus,* 3; *Liocyma fluctuosa,* 5.

Station 8 was in a transition area marking the beginning of the rubble zone and was not very productive of animal life: Bryozoans—*Costazia nordenskjoldi,* 3; *Alcyonidium polyoum* (C) (on snail shells containing hermit crabs). Amphipods—Caprellid sp. No. 2, 10. Decapods—*Pagurus trigonocheirus,* 3.

Station 9 was in a small-stone and gravel area of the rubble zone. The animal life was abundant: Sponges—*Choanites lütkeni,* 3. Hydroids—*Obelia* sp., few col. Nemerteans—*Amphiporus lactifloreus,* 6; *Tetrastemma* sp., 7. Bryozoans—*Tricellaria erecta* (C); *Scrupocellaria scabra* var. *paenulata* (C); *Pachyegis princeps* (C); *Rhamphostomella fortissima,* few; *R. gigantea,* n. sp., 1 large; *Cystisella fragilis,* few; *Costazia nordenskjoldi,* 5; *Cauloramphus cymbaeformis* (C). Decapods—*Hyas coarctatus alutaceus,* 8. Pelecypods—*Hiatella arctica* (AA). Gastropods—*Dendronotus frondosus* (?), 2; *Dendronotus* sp. (white), 2. Tunicates—*Styela coriacea,* 4; *S. rustica macrenteron,* 6.

Station 10 was in a region of abundant animal life in the rubble zone (even though half the material brought up in the dredge was dead *Hiatella* shells): Sponges—*Halichondria lambei* (C). Hydroids—*Obelia* sp., few col.; *Lafoeina maxima* (A); *Thuiaria* sp. (C); unidentified calyptoblast (C). Anthozoans—Sea anemones (C). Turbellarians—*Notoplana atomata,* 4. Nemerteans—*Amphiporus lactifloreus,* 3; *A. macracanthus,* 4. Brachiopods—*Diestothyris spitzbergensis,* 6, plus shells. Bryozoans—*Eucratea loricata* (C); *Bidenkapia spitzbergensis,* several; *Tegella magnipora,* n. sp., few; *Dendrobeania murrayana,* 4; *Hippothoa hyalina* (C); *Pachyegis princeps* (C); *Parasmittina alaskensis,* n. sp., few; *Cystisella fragilis,* few; *C. bicornis,* n. sp., few; *Mucronella abyssicola,* few; *M. ventricosa,* few; *Costazia nordenskjoldi,* 9; *Diplosolen obelium* (C); *Cauloramphus cymbaeformis* (C). Entroprocts—*Barentsia gorbunovi,* 2. Cirripedes—*Balanus crenatus* (A). Isopods—*Phryxus abdominalis,* 2 pairs. Amphipods—*Rhachotropis aculeata,* 7; *Ischyrocerus commensalis,* 3; *Ericthonius hunteri* (C). Decapods—*Sabinea septemcarinata,* 2; *Pagurus trigonocheirus,* 9; *Eualus gaimardi,* 21. Pelecypods—*Hiatella arctica* (AAA). Gastropods—*Dendronotus frondosus* (?), 1.

Station 11, at the shoreward edge of the mud zone, yielded nothing but holothurians—*Myriotrochus rinki,* 8.

Station 14 was obviously in a good area but because of a strong current and wind working at cross purposes the dredge had to be

taken in before the haul was complete. Animals: Bryozoans—*Rhamphostomella gigantea,* 1 large; *Alcyonidium polyoum* (C). Amphipods—*Eurystheus melanops,* 23; *Protomedeia fasciata,* 125; unidentified caprellid, sp. No. 2, 12. Decapods—*Pagurus splendescens,* 4; *P. trigonocheirus,* 33; *Chionocetes opilio,* 5. Pelecypods—*Cardita crassidens,* 3; *Hiatella arctica* (AA). Gastropods—*Volutopsius stefanssoni,* 1; *Buccinum tenue,* 2; *B. angulosum,* 2; *Boreotrophon* sp., 3.

STATION 15 was in the typical mud zone and few animals were taken: Bryozoans—*Borgiola pustulosa,* n. sp., encrusting on shell. Amphipods—*Sympleustes uncigera,* 5. Decapods—*Argis lar,* 2. Pelecypods—*Macoma calcarea* (C).

STATION 16 was in the area of the gravel zone but it was a region in which the sand had become segregated from the gravel and it formed a special habitat for certain animals: Amphipods—*Acanthostepheia behringiensis,* 2. Gastropods—*Aldisa zetlandica* (?), 2. Tunicates—*Rhizomolgula globularis* (AAA). (The dredge came up one-third full of these spherical, sand-encrusted animals.) Fishes—flatfish, 7 (about 1.5 in. long).

STATION 17 was in the typical mud zone. Animals: Hydroids—*Tubularia* sp., 1. Nemerteans—*Amphiporus pacificus,* 1; *Tetrastemma aberrans,* 2. Bryozoans—*Alcyonidium disciforme* (C). Amphipods—*Byblis gaimardii* (C); *Pleustes panoplus,* 1; *Weyprechtia heuglini,* 6; caprellid sp. No. 2, 17. Tunicates—*Styela rustica macrenteron,* 4.

STATION 18 was also in the mud zone. Since an attempt was being made to locate the border of the rubble zone, only a short haul was made. Animals: Bryozoans—*Costazia nordenskjoldi,* 3; *Alcyonidium polyoum* (C). Amphipods—caprellid sp. No. 2, 10. Decapods—*Pagurus trigonocheirus,* 3.

STATION 19 was also in a muddy area, so only a short haul was made. Animals: Amphipods—*Sympleustes karianus,* 1 (2d record for this species); *Rhachotropis aculeata,* 5; *Eurystheus melanops,* 6. Decapods—*Pandalus goniurus,* 2; *Sabinea septemcarinata,* 3.

STATION 20 was in the rubble zone and was one of the richest in animal life. No other station yielded so many echinoderms as this one. Animals: Sponges—*Leuconia ananas,* 3; *Myxilla incrustans,* 2 lots (around barnacles); *Topsentia disparilis,* 3. Hydroids—*Tubularia* sp., 3; unidentified gymnoblast (A); *Obelia* sp. (C); *Thuiaria* sp. (C); unidentified calyptoblasts, 3 species (C). Anthozoans—sea anemones (AA). Turbellarians—*Notoplana atomata,* 4. Nemerteans—*Amphiporus macracanthus,* 4. Sipunculids—*Golfingia mar-*

garitacea, 10. Bryozoans—*Bidenkapia spitzbergensis* (C); *Scrupocellaria scabra* var. *paenulata* (C); *Dendrobeania murrayana* (C); *Hippothoa expansa* (C); *Posterula sarsi* (C); *Pachyegis princeps* (A); *Porella compressa* (C); *Rhamphostomella gigantea* (C); *Costazia surcularis* (C); *C. ventricosa* (C); *Myriozoella plana* (C); *Myriozoum subgracile* (A); *Diaperoecia intermedia* (C), on shells and rocks; *D. johnstoni* (C); *Lichenopora verrucaria* (A). Ophiurans—*Gorgonocephalus stimpsoni,* 6; *Amphiuri sundevalli,* 16+; *Ophiopholis aculeata* (A); *Ophiura robusta* (A). Asteroids—*Crossaster papposus,* 2; *Henricia sanguinolenta,* 1. Echinoids—*Strongylocentrotus drobachiensis,* 173. Holothurians—*Psolus fabricii,* 118. Polychaetes—*Eusyllis blomstrandi,* 17; *Amphitrite cirrata,* 5; *Lanassa venusta,* 10; *Nicolea venustula,* 12; *Polycirrus medusa,* 6. Ostracods—*Philomedes globosus,* 2. Cirripedes—*Balanus crenatus* (C); *B. rostratus apertus* (C). Amphipods—*Aristias tumida* (from atrial cavity of tunicate *Molgula retortiformis*), 4; *Stegocephalopsis ampulla,* 1; *Gitanopsis arctica,* 2; *Acanthonotozoma serratum,* 3; *Sympleustes pulchellus,* 3; *S. uncigerus* 25; *Maera danae,* 6; *Photis reinhardi,* 7; *Eurystheus melanops,* 29; *Ischyrocerus latipes* (A); *I. commensalis,* 16; *Ericthonius hunteri,* 30; *E. tolli* (C); caprellids, sp. No. 1 (C), species No. 2 (A). Decapods—*Eualus gaimardi,* 87; *Lebbius polaris,* 2; *Pagurus trigonocheirus,* 36; *Hyas coarctatus alutaceus,* 21. Pelecypoda—*Astarte montagui* (C); *Serripes groenlandicus,* 3; *Hiatella arctica* (AAA). Gastropods—*Volutopsius stefanssoni,* 2; *Plicifusus kroyeri,* 1; *P. verkruzeni,* 3; *Colus spitzbergensis,* 2; *Buccinum glaciale,* 9; *B. morchianum,* 2; *B. plectrum,* 3; *Boreotrophon clathratus,* 8; *Boreotrophon* sp., 5; *Crepidula grandis,* 3. Tunicates—*Amaroucium fragile,* several; *Aplidiopsis pannosum,* 2; *Didemnum albidum,* 8; *Ascidia callosa,* 3; *Dendrodoa pulchella* (C); *D. grossularia,* 9; *Styela coriacea,* 16; *S. rustica macrenteron* (C); *Boltenia echinata,* 8; *B. ovifera,* 5; *Halocynthia aurantium,* 6; *Molgula* sp. No. 2, 10. Enteropneusts—Unidentified balanoglossid, 3.

Station 21 was in the rubble zone but there was more gravel than in typical rubble bottom. Animals: Anthozoans—Sea anemones (C). Bryozoans—*Rhamphostomella gigantea,* 1 large col.; *Myriozoella plana* (C); *Myriozoum subgracile* (C); *Crisia eburnea* (C); *Lichenopora verrucaria* (A). Echinoids—*Strongylocentrotus drobachiensis,* 37. Holothurians—*Psolus fabricii* (AAA). Decapods—*Spirontocaris arcuata,* 3; *Pagurus splendescens,* 3. Gastropods—*Plicifusus kroyeri,* 1; *Boreotrophon clathratus,* 2. Tunicates—*Molgula* sp. No. 1, 2, sp. No. 2, 9.

STATION 22 was in the typical rubble zone and yielded an abundance of species and individuals: Anthozoans—Sea anemones (C). Turbellarians—*Notoplana atomata,* 2. Nemerteans—*Amphiporus angulatus,* 3. Bryozoans—*Tricellaria erecta* (C); *Porella compressa,* 1 large; *Costazia ventricosa,* 1; *Flustrella corniculata* (C). Entoprocts—*Barentsia gorbunovi,* few. Ophiurans—*Gorgonocephalus stimpsoni,* 2. Echinoids—*Strongylocentrotus drobachiensis,* 33. Holothurians—*Psolus fabricii* (AA). Isopods—*Janiralata* sp., 9. Amphipods—*Mesometopa gibbosa,* n. sp., 6; *Stenothoides angusta,* n. sp., 8; *Sympleustes uncigerus,* 13; *Guernea nordenskiöldi,* 6; *Eurystheus melanops,* 7; *Dulichia porrecta,* 2. Decapods—*Sclerocrangon boreas,* 2; *Eualus gaimardi,* 11; *Pagurus splendescens,* 6; *Hyas coarctatus alutaceus,* 8. Pelecypods—*Hiatella arctica* (AA). Gastropods—*Margarites frigidus,* 9; *M. vahli,* 5; *Lepeta caeca,* 2. Tunicates—*Dendrodoa pulchella* (C); *Boltenia echinata,* 5.

STATION 23 was also in the typical rubble zone, about 6 miles from shore—as far as it was possible to go on account of the ice. Animal life was abundant: Hydroids—*Tubularia* sp., 2. Anthozoans—Sea anemones, 123. Turbellarians—*Notoplana atomata,* 2. Nematodes—*Thoracostoma* sp., 9 (from rocks broken apart). Nemerteans—*Amphiporus groenlandicus,* 2. Bryozoans—*Eucratea loricata* (C); *Bidenkapia spitzbergensis,* 2; *Euritina arctica,* n. sp., few; *Ragionula rosacea,* 3; *Pachyegis princeps,* 6; *Rhamphostomella gigantea* (C); *Costazia ventricosa* (C); *Myriozoella plana* (C); *Lichenopora verrucaria* (C). Polychaetes—*Gattyana cirrosa,* 11; *Potamilla reniformis,* 11. Ophiurans—*Gorgonocephalus stimpsoni,* 4; *Amphiura sundevalli,* 17+; *Ophiopholis aculeata,* 29; *Ophiura robusta,* 15. Echinoids—*Strongylocentrotus drobachiensis,* 73. Holothurians—*Psolus fabricii,* 86. Copepods—*Herpyllobius arcticus,* 2. Amphipods—*Ericthonius tolli* (C). Decapods—*Hyas coarctatus alutaceus,* 6. Gastropods—*Pyrulofusus deformis,* 1; *Neptunea* sp., 4. Tunicates—*Aplidiopsis pannosum,* 3; *Chelyosoma macleayanum,* 3; *Dendrodoa pulchella,* 6; *D. grossularia,* 9; *Halocynthia aurantium,* 3.

STATION 24 was at the very edge of the rubble zone and was characterized by pebbles rather than stones, a large quantity of old broken shells (largely *Hiatella*), and considerable mud. It was over a mile nearer shore than Station 21, and it was not nearly so rich in animal life. Animals: Hydroids—Unidentified calyptoblast (C); *Obelia* sp., few col.; *Lafoeina maxima* (A); *Sertularella* sp. (?) (C). Bryozoans—*Carbasea carbasea,* 6; *Tricellaria erecta* (C); *Porella compressa,* 3 large; *Rhamphostomella fortissima,* 2 large; *Costazia nordenskjoldi* (C); *Alcyonidium pedunculatum,* several. Cumaceans—2

large. Decapods—*Argis lar,* 3; *Eualus fabricii,* 3. Pelecypods—*Hiatella arctica* (AA). Tunicates—*Aplidiopsis pannosum,* 2; *Halocynthia aurantium,* 2; *Molgula* sp. No. 1, 2.

Station 25 was in the rubble zone but the large stones that came up in the dredge were not so covered with animals as were the smaller stones at most of the stations in the rubble zone. Animals: Ophiurans—*Amphiodia craterodmeta,* 2. Amphipods—*Ischyrocerus latipes,* 14. Decapods—*Eualus gaimardi,* 11. Pelecypods—*Nucula tenuis,* 14. Gastropods—*Neptunea* sp., 2. Tunicates—*Boltenia ovifera,* 5.

Station 26 was in the rubble zone and although it was 5 feet deeper than Station 20 it yielded far fewer species and individuals than did the latter. Animals: Bryozoans—*Plagioecia ambigua,* n. sp., 1. Amphipods—*Stegocephalus inflatus,* 1. Decapods—*Pandalus goniurus,* 2; *Spirontocaris spina,* 2; *Hyas coarctatus alutaceus,* 16. Pelecypods—*Astarte montagui,* 12. Gastropods—*Neptunea* sp., 2; *Boreotrophon clathratus,* 1; *B. beringi,* 2. Tunicates—*Boltenia echinata,* 4.

Station 27 was rich in both species and individuals. Mollusks were prominent in the hauls. Animals: Sponges—*Halichondria lambei* (C). Hydroids—*Tubularia* sp., 3. Nemerteans—*Tubulanus annulanus,* 3+. Sipunculids—*Golfingia margaritacea,* 5. Bryozoans—*Tegella magnipora,* n. sp., few; *Pachyegis princeps* (A). Polychaetes—*Gattyana cirrosa,* 10; *Syllis cornuta,* 11; *Cirratulus cirratus,* 15; *Idanthyrsus armatus,* 4; *Potamilla neglecta,* 5. Ophiurans—*Ophiura robusta,* 3. Asteroids—*Solaster endeca,* 1. Isopods—*Janiralata* sp., 3. Amphipods—*Pleustes medius,* 3; *Eusirus cuspidatus,* 5; *Sympleustes uncigera,* 4; *Paramphithoë polyacantha,* 2. Decapods—*Hyas coarctatus alutaceus,* 6. Pelecypods—*Nuculana* sp., 3; *Pecten islandicus,* 2; *Musculus corrugatus,* 7; *Astarte borealis,* 2; *A. montagui* (A); *Lyonsia norvegica,* 1. Gastropods—*Plicifusus verkruzeni* 2; *Colus spitzbergensis,* 3; *Neptunea* sp., 3; *N. ventricosa,* 3. *Buccinum glaciale,* 5; *Onchidiopsis glacialis* (?), 1; *Margarites costalis* var. *grandis,* 17; *Lepeta caeca,* 2. Amphineurans—*Trachydermon albus,* 7. Tunicates—*Chelyosoma macleayanum,* 9.

Station 28 was in the typical mud zone and yielded the usual small number of animals: Anthozoans—*Halcampa duo-decimcirrata* (?), 1. Decapods—*Chionocetes opilio,* 35. Pelecypods—*Macoma calcarea,* 5.

Station 29 was on the shoreward side of Station 32 (see below). The rubble bottom of this station was rich in animal life: Sponges—*Craniella* sp. nov., 1. Hydroids—*Hydractinia* sp. (C). Bryozoans—*Eucratea loricata* (A); *Ragionula rosacea,* 3; *Hippodiplosia cancel-*

lata, R; *Porella compressa*, 1 large; *Costazia surcularis*, several; *Diplosolen obelium* (C). Cirripedes—*Clistosaccus paguri*, 1; *Peltogaster depressus*, 1; *Balanus balanus* (C); *B. rostratus apertus* (C). Cumaceans—*Diastylis dalli*, few. Amphipods—*Onisimus affinis*, 3; *Eusirus cuspidatus*, 4. Pelecypods—*Pecten islandicus*, 2; *Musculus discors*, 30 (up to 9 mm.). Gastropods—*Ptychatractus occidentalis*, 2; *Pyrulofusus deformis*, 1 small; *Beringius stimpsoni*, 2; *Colus spitzbergensis*, 2; *Neptunea* sp., 3; *Buccinum plectrum*, 5; *Trichotropis bicarinata*, 2. Amphineurans—*Symmetrogephyrus vestitus*, 5.

STATION 30-31 was on the oceanward side of Station 32 (see below). The rubble bottom here was not quite so rich in animal life as that on the shoreward side of Station 32. Some of the largest sea urchins found were taken at this station but there were only a few specimens. Animals: Sponges—*Polymastia andrica*, ½ (the only specimen taken of this red, cylindrical sponge). Anthozoans (octocoral)—*Eunephthya rubiformis*, several col. Bryozoans—*Hincksina gothica*, n. sp. (C); *Emballotheca stylifera* (C); *Porella minuta* (C); *Cystisella fragilis*, few; *Lichenopora canaliculata*, few; *L. verrucaria* (A). Ophiurans—*Gorgonocephalus stimpsoni*, 2. Echinoids—*Strongylocentrotus drobachiensis*, several. Amphipods—*Photis reinhardi*, 5. Gastropods—*Beringius stimpsoni*, 2; *Neptunea ventricosa*, 2; *Buccinum plectrum*, 10; *Margarites costalis*, 6. Amphineurans—*Trachydermon albus*, 5.

STATION 32 was a complete surprise. It was a canyon 12.1 miles from shore, of undetermined length, about 0.25 mile wide and 741 feet deep, with fairly abrupt walls. The floor of the ocean was at a depth of 438 feet on the shoreward side of the canyon and 522 feet on the oceanward side. The substratum of the canyon was mud, but it was soft, and not stiff, sticky, or clayey like that of the mud zone near shore. As far as could be determined, the entire floor of the canyon was covered with worm tubes of the terebellid *Pista maculata*. Dredge hauls brought up bushels of them. Dr. Pettibone identified 27 other species of polychaetes that occurred in lesser numbers among the tubes of *Pista*. Of these 27 species 11 were tube dwellers also: *Flabelligera affinis*, 1; *Nicomache lumbricalis*, 1; *Pectinaria granulata*, 5; *P. hyperborea*, 10; *Nicolea venustula*, 1; *Terebellides stroemi*, 1; *Thelepus cincinnatus*, 1; *Euchone analis*, 1; *Potamilla neglecta*, 9; *Sabella crassicornis*, 3; and *Spirorbis granulatus*, 1. There were 5 species of polynoids: *Arcteobia anticostiensis*, 1; *Enipo gracilis*, 1; *Gattyana cirrosa*, 11; *Harmothoë extenuata*, 43; and *H. imbricata*, 1. *Arcteobia anticostiensis* is known to be commensal with *Pista flexuosa* (Labrador) and *Enipo gracilis* with *Nichomache lumbricalis* (Alaska;

Halifax, Nova Scotia; and Cape Cod, Mass.). The remaining 11 species were: *Phyllodoce groenlandica,* 1; *Autolytus alexandri,* 2; *Eusyllis blomstrandi,* 1; *Exogone naidina,* 1; *Syllis cornuta,* 4; *S. fasciata,* 16; *Nephtys discors,* 1; *N. paradoxa,* 2; *Lumbrineris fragilis,* 1; *Chaetozone setosa,* 1; and *Brada inhabilis,* 5.

It was impossible to pick over minutely the entire mass of worm tubes of *Pista* brought up; they were hard to untangle, and it was very difficult to remove a worm intact from its tube. A few (about 115)—both tubes with worms and worms that had been removed—were sent to Dr. Pettibone.

Other animals from this station were: Sponges—*Craniella* sp. nov., 2; *Echinoclathria beringensis,* 3. Nematodes—unidentified species (C). Nemerteans—*Amphiporus angulatus,* 10+; *A. groenlandicus,* 2+; *A. lactifloreus,* 3; *Cerebratulus marginatus,* 1. Sipunculids—*Golfingia margaritacea,* 8. Priapulids—*Priapulus caudatus,* 1. Brachiopods—*Diestothyris spitzbergensis,* 5. Bryozoans—*Eucratea loricata* (C-A); *Terminoflustra membranaceo-truncata,* 1 large (with the exception of one small colony, this species was taken only at this station and Station 36); *Alcyonidium enteromorpha* (a new species) (A). Ophiurans—*Amphiura sundevalli,* 20; *Ophiura sarsi,* 49; *O. robusta,* 19. Asteroids—*Leptasterias groenlandica* forma *cribraria,* 5; *Henricia sanguinolenta,* 1. Ostracods—*Philomedes globosus,* 13; *Asterope mariae,* 1; *Cytheridea punctillata,* 5; *Cyprideis sorbyana,* 2. Copepods—*Herpyllobius arcticus,* 3. Cumaceans—*Diastylis dalli,* few. Amphipods—*Pontoporeia femorata,* 18 (these and two from Station 36 were the only ones obtained that were not washed ashore). Pelecypods—*Musculus discors* var. *laevigatus,* 19; *M. corrugatus,* 13; *Mysella planata,* 4. Gastropods—*Neptunea* sp., 3; *Tachyrhynchus reticulatus,* 4; *Polinices pallidus,* 2; *P. monteronus,* 2; *Margarites frigidus,* 14. Tunicates—*Didemnum albidum,* 23.

Station 33 was in a good area of the rubble zone, for it yielded a large number of species and of individuals. Many of the rocks were perforated with burrows and holes. Those areas in which *Psolus* and sea urchins were abundant were always rich in other animal life: Sponges—*Leuconia* sp. nov., 6+; *Echinoclathria beringensis,* several; *Myxilla incrustans,* few. Hydroids—*Tubularia* sp., 8; *Thuiaria elegans,* 11; unidentified calyptoblast, many large. Anthozoans (octocoral)—*Eunephthya rubiformis* (C). Turbellarians—*Notoplana atomata,* 4. Nemerteans—*Amphiporus angulatus,* 3; *Tetrastemma candidum,* 3. Bryozoans—*Eucratea loricata* (C); *Bidenkapia spitzbergensis* (A); *Tricellaria erecta* (C); *Dendrobeania murrayana* (A); *Porella compressa* (C); *Myriozoella plana* (C); *Myriozoum*

subgracile (C); *Lichenopora verrucaria* (A). Polychaetes—*Syllis fasciata,* 15; *Chone infundibuliformis,* 5; *Spirorbis spirillum,* 13. Asteroids—*Leptasterias arctica,* 1. Echinoids—*Strongylocentrotus drobachiensis,* several. Cirripedes—*Balanus crenatus* (young) (AA). Isopods—*Janiralata* sp., 4; *Munna* sp., 3. Amphipods—*Metopa clypeata,* 5; *Proboloides nordmanni,* 3; *Ericthonius tolli,* 15; *Eurystheus melanops,* 6; *Ischyrocerus latipes* (C); *I. commensalis,* 3. Pelecypods—*Musculus corrugatus,* 4; *Hiatella arctica* (A). Gastropods—*Plicifusus verkruzeni,* 3; *Neptunea* sp., 2; *Natica clausa,* 3; *Margarites vahli,* 7. Tunicates—*Didemnum albidum,* 14; *Boltenia echinata,* 5; *B. ovifera,* 23; *Halocynthia aurantium,* 2; *Molgula griffithsi,* 4; *Molgula* sp. No. 2 (A).

STATION 34 was in the shoreward part of the mud zone and yielded little besides holothurians—*Myriotrochus rinki* (AA).

STATION 35 was in the rubble zone but, compared with other areas with similar bottom, its animal life was relatively sparse as far as individuals were concerned although there were a large number of species. Many of the stones and rocks were porous and brittle, and some were riddled with holes and tunnels that provided refuge for polychaetes. Only a very few live snails were found at this station, and Foraminifera, usually abundant on such bottoms, were very scarce. Amphipods were also scarce, probably because of the scarcity of hydroids and bryozoans. Animals collected were: Anthozoans (octocoral)—*Eunephthya rubiformis,* few. Turbellarians—*Notoplana atomata,* 3. Brachiopods—*Hemithyris psittacea,* 11; *Diestothyris spitzbergensis,* 3. Bryozoans—*Eucratea loricata* (C); *Dendrobeania murrayana* (C); *Microporella arctica,* few; *Smittina bella* (C); *Proboscina incrassata* (C); *Lichenopora verrucaria* (A); *Flustrella corniculata* (A); *Vesicularia fasciculata,* n. sp., few. Entoprocts—*Barentsia gorbunovi,* few. Polychaetes—*Gattyana cirrosa,* 10; *Sabella crassicornis,* 3; *Syllis fasciata,* 18; *Cirratulus cirratus,* 14; *Capitella capitata,* 9. Echinoids—*Strongylocentrotus drobachiensis,* several. Cirripedes—*Balanus rostratus apertus* (C). Isopods—*Janiralata* sp., 4. Amphipods—*Maera danae,* 6. Decapods—*Pagurus trigonocheirus* (C). Gastropods—*Epitonium greenlandicum,* 1; *Crepidula grandis,* several. Amphineurans—*Symmetrogephyrus vestitus,* 1. Tunicates—*Chelyosoma macleayanum,* 4 (exceptionally large); *Boltenia ovifera,* 4.

STATION 36 was a muddy area in the rubble zone. In many respects it was like Station 32, having a soft, muddy bottom, with large masses of the tubes of the terebellid *Pista maculata.* Several species of animals, such as the bryozoans *Terminoflustra membranaceo-trun-*

cata and *Alcyonidium enteromorpha* (a new species), were restricted to these two stations. There were a few large rocks that were entirely lacking at Station 32. Animals: Hydroids—*Lafoeina maxima* (AAA). Nematodes—Unidentified species (associated with *Alcyonidium enteromorpha,* hence found only here and at Station 32). Nemerteans—*Lineus ruber,* 1; *Tetrastemma candidum,* 3. Bryozoans—*Eucratea loricata* (A); *Electra crustulenta* (A); *Terminoflustra membranaceo-truncata,* 1 large col.; *Mucronella microstoma* (C); *Costazia nordenskjoldi* (C); *Alcyonidium enteromorpha* (C) (see Station 32); *Flustrella corniculata* (C). Entoprocts—*Barentsia gorbunovi,* 1 very large. Polychaetes—*Pectinaria hyperborea,* 3; *Pista maculata* (AAA). Ophiurans—*Amphiura sundevalli,* 8; *Ophiura robusta,* 9; *O. sarsi,* 18; *Ophiopholis aculeata,* 5. Amphipods—*Pontoporeia femorata,* 2; *Ischyrocerus latipes,* 7; *Unciola leucopis,* 3. Pelecypods—*Nuculana* sp., 6; *Musculus discors* var. *laevigatus,* 54; *M. corrugatus,* 25; *Cardita crassidens,* 3; *Hiatella arctica,* dozens (3-22 mm.). Gastropods—*Tachyrhynchus reticulatus,* 4; *Aquilonaria turneri,* 1; *Margaritopsis pribiloffensis,* 2; *Margarites frigidus,* 21. Tunicates—*Molgula griffithsi,* 4.

STATION 37 was in an area of the rubble zone that was above average in the richness of its fauna. The larger perforated rocks afforded space for attachment for such animals as erect bryozoans and tunicates and the holes in the rocks provided refuge for worms and other animals. Animals: Sponges—*Myxilla incrustans,* 4. Hydroids—*Thuiaria elegans,* 10. Anthozoans (octocoral)—*Eunephthya rubiformis,* several large. Nemerteans—*Amphiporus pacificus,* 3+; *Tetrastemma* sp., 2+. Sipunculids—*Golfingia margaritacea,* 11. Brachiopods—*Hemithyris psittacea,* 4. Bryozoans—*Dendrobeania murrayana* (C); *Stomachetosella distincta,* few; *Ragionula rosacea,* 8 col.; *Emballotheca stylifera* (C); *Smittina bella* (A); *Costazia ventricosa* (C); *Myriozoum subgracile* (C); *Plagioecia grimaldii,* few; *Diplosolen obelium* (A); *Lichenopora verrucaria* (A); *Flustrella corniculata* (AA); *F. gigantea* (C). Polychaetes—*Arcteobia anticostiensis,* 4; *Eunoë oerstedi,* 4; *Sphaerosyllis erinaceus,* 13; *Syllis cornuta,* 14; *Chaetozone setosa,* 7; *Cirratulus cirratus,* 21; *Capitella capitata,* 7; *Lanassa venusta,* 7. Ophiurans—*Amphiura sundevalli,* 5; *Ophiopholis aculeata,* 12. Amphipods—*Metopa clypeata,* 5; *Metopelloides stephenseni,* 1; *Ericthonius tolli,* 17; *Maera danae,* 13; *Eurystheus melanops,* 36; *Ischyrocerus latipes,* 6; *Paradulichia typica,* 2. Decapods—*Eualus gaimardi,* 15; *Spirontocaris phippsi,* 2. Pelecypods—*Hiatella arctica* (A). Gastropods—*Crepidula grandis,* 3; *Lepeta caeca,* 10; *Oenopota tenuilirata,* 2. Amphineurans—*Trachydermon*

albus, 7. Tunicates—*Didemnum albidum,* 10; *Chelyosoma macleayanum,* 4; *Boltenia echinata,* 12; *B. ovifera,* 5.

STATION 38 was in a less productive area than the above station. The bottom of pebbles, gravel, and mud does not provide as much attachment space as does the type of bottom in Station 37. Animals: Hydroids—*Tubularia* sp., 3; *Thuiaria elegans,* 4. Anthozoans—*Cerianthus* sp., 8. Bryozoans—*Eucratea loricata* (C). Entoprocts—*Barentsia gorbunovi* (C). Amphipods—*Anonyx nugax,* 3; *Byblis gaimardii,* 5; *Melita dentata,* 5. Pelecypods—*Liocyma fluctuosa,* 3.

STATION 39 was either a muddy spot in the rubble zone or else a tongue of the muddy zone extending into the rubble zone. Animals: Polychaetes—*Nephtys ciliata,* 6; *Sternaspis scutata,* 3; *Chone duneri,* 3. Pelecypods—*Macoma calcarea,* 14.

STATION 40, in the gravel zone, yielded little of note besides Nemerteans—*Tubulanus capistratus,* 1; and Gastropods—*Aldisa zetlandica* (?), 1.

STATION 41 was in one of the less productive areas of the rubble zone. There were few stones of intermediate size and the contrast between the gravel and small stones and the large rocks was marked. However, the haul was satisfactory and several noteworthy animals were brought up: Turbebellarians—*Acerotisa arctica* (new), 2. Nemerteans—unidentified sp., 6. Brachiopods—*Hemithyris psittacea,* 6. Bryozoans—*Dendrobeania murrayana,* 4; *Ragionula rosacea,* 4; *Emballotheca stylifera* (C); *Porella minuta* (C); *Mucronella microstoma* (C); *Oncousoecia canadensis* (C); *Borgiola pustulosa,* n. sp., 1 very large col.; *Lichenopora verrucaria* (A). Polychaetes—*Trichobranchus glacialis,* 6. Holothurians—*Psolus fabricii* (C). Amphipods—*Macra danae,* 7; *Unciola leucopis,* 5. Decapods—*Pagurus trigonocheirus,* few; *Hyas coarctatus alutaceus,* few. Pelecypods—*Nuculana minuta,* 3; *Astarte borealis,* 3; *A. montagui* (C) (many of them drilled); *Yoldia myalis* (C). Gastropods—*Natica clausa* (C); *Boreotrophon clathratus,* 3; *B. beringi,* 1; *B. pacificus,* 1.

STATION 42, in the rubble zone, with some perforated rocks, was very rich in animal life: Hydroids—*Thuiaria elegans,* 16; unidentified calyptoblast No. 1 (AA); calyptoblast No. 2 (C). Anthozoans—unidentified sea anemone (C). Nemerteans—*Amphiporus angulatus,* 8; *Tetrastemma candidum,* 4; *Tubulanus albocinctus,* 3. Sipunculids—*Golfingia margaritacea,* 10. Bryozoans—*Hincksina gothica,* n. sp. (C); *Eucratea loricata* (A); *Tricellaria erecta* (A); *Ragionula rosacea,* 4; *Porella minuta* (C); *Costazia surcularis* (C); *Myriozoum subgracile* (A); *Oncousoeicia canadensis* (C); *Diplosolen obelium* (C); species encrusting rocks (AA). Entoprocts—

Coriella stolonata, few. Polychaetes—*Eunoë nodosa,* 5; *E. oerstedi,* 4; *Gattyana cirrosa,* 18; *Harmothoë extenuata,* 22; *H. imbricata,* 18; *Cirratulus cirratus,* 22. Asteroids—*Leptasterias arctica,* 1. Echinoids—*Strongylocentrotus drobachiensis,* several large. Holothurians—*Psolus fabricii,* 7. Cirripedes—*Balanus crenatus* (A). Amphipods—*Metopa robusta,* 2; *Syrrhoe crenulata,* 3; *Sympleustes uncigerus,* 30; *Melita dentata,* 4; *Ischyrocerus latipes,* 8; *Unciola leucopis,* 6. Decapods—*Pagurus trigonocheirus,* several; *Hyas coarctatus alutaceus,* several (few large males). Pelecypods—*Pecten islandicus,* 3 (very young); *Musculus corrugatus,* 9; *Astarte borealis,* few; *A. montagui* (A); *Hiatella arctica* (A). Gastropods—*Natica clausa* (C); *Boreotrophon* sp. (C); *Margarites costalis* (C); *Buccinum* (several species), 1 or 2 each. Cephalopods—*Benthoctopus hokkaidensis,* 1 (the only specimen taken).

Station 43 was in a gravel area of the rubble zone with a large amount of mud. There were chunks in which the gravel was cemented together with mud. The station was fairly productive of animal life: Foraminifera (A). Hydroids—*Thuiaria elegans,* 6; *Lafoeina maxima,* few. Anthozoans (octocoral)—*Eunephthya rubiformis,* few. Nemerteans—*Amphiporus pacificus,* 5+. Echiuroids—*Echiurus echiurus alaskanus,* 1 small. Bryozoans—*Eucratea loricata* (A); *Carbasea carbasea,* several col.; *Tricellaria erecta* (A); *Costazia nordenskjoldi* (A); *Flustrella corniculata* (C). Polychaetes—*Harmothoë extenuata* (C); *H. imbricata* (C); *Pectinaria granulata,* 14; *Terebellides stroemi,* 9; *Chone infundibuliformis,* 6. Cirripedes—*Balanus crenatus* (AA). Isopods—*Phryxus abdominalis,* 2 pairs. Amphipods—*Byblis gaimardii,* 9+; *Ischyrocerus latipes,* 33. Decapods—*Eualus gaimardi,* 16. Pelecypods—*Nuculana minuta,* few; *Yoldia myalis,* 12; *Macoma calcarea,* 8; *Hiatella arctica* (A) (nestling among barnacles). Gastropods—*Piliscus commodus,* 6; *Oenopota harpa,* 2; *Natica clausa,* C.

Station 44, in a typical rubble-zone area, was exceedingly rich in marine invertebrates. The abundance of animal life was comparable with that of Station 20. Echinoderms and sea anemones formed a conspicuous part of the fauna from Station 20, and mollusks and polychaetes were predominant forms from Station 44. Animals: Sponges—*Choanites suberea,* 2; *Echinoclathria beringensis,* 2; *Halichondria lambei* (C); *Topsentia disparilis* (C). Hydroids—*Hydractinia* sp. (C); *Lafoeina maxima* (AA); *Thuiaria elegans,* 6; *Thuiaria* sp. (A); unidentified calyptoblast (C). Turbellarians—*Acerotisa arctica,* 2. Brachiopods—*Hemithyris psittacea,* 12. Bryozoans—*Eucratea loricata* (AA); *Electra crustulenta* (A); *Bidenkapia spitzbergensis*

(C); *Dendrobeania murrayana* (A); *Emballotheca stylifera* (C); *Pachyegis princeps* (A); *Escharoides jacksoni,* few; *Porella compressa* (C); *P. minuta* (C); *Smittina bella* (A); *Mucronella microstoma,* (C); *Costazia surcularis* (A); *C. ventricosa* (A); *Borgiola pustulosa,* n. sp. (C); *Lichenopora verrucaria* (A); *Alcyonidum polyoum* (A); *Flustrella corniculata* (A). Polychaetes—*Arcteobia anticostiensis,* 4; *Harmothoë extenuata,* 31; *H. imbricata,* 13; *Eumida minuta,* 28; *Autolytus fallax,* 13; *A. alexandri,* 10; *Exogone naidina,* 49; *Sphaerosyllis erinaceus,* 11; *Syllus cornuta,* 17; *S. fasciata,* 41; *Chaetozone setosa,* 8; *Cirratulus cirratus,* 31; *Nicomache lumbricalis,* 7. Amphiurans—*Gorgonocephalus stimpsoni,* few. Holothurians—*Psolus fabricii,* 34. Cirripedes—*Balanus crenatus* (AAA); *B. rostratus apertus,* few. Copepods—*Schizoproctus inflatus,* 2. Isopods—*Synidotea bicuspida,* 2; *Munna* sp., 24. Amphipods—*Photis reinhardi,* 25; *Eurystheus melanops,* 6; *Ischyrocerus latipes,* 9; *Unciola leucopis,* 4. Decapods—*Sclerocrangon boreas,* 4; *Eualus gaimardi,* 18; *Pagurus trigonocheirus,* 12; *Hyas coarctatus alutaceus,* 15. Pelecypods—*Musculus corrugatus,* 25 small; *Astarte montagui* (AAA); *Cardita crassidens,* 3. Gastropods—*Ptychatractus occidentalis,* 3; *Neptunea ventricosa,* 2; *Buccinum plectrum,* 4; *B. fringillum,* 2 (the only specimens taken); *Boreotrophon* sp. (C); *Piliscus commodus,* 9; *Aquilonaria turneri,* 1; *Natica clausa,* 5; *Onchidiopsis glacialis,* 1; *Molleria costulata,* 3; *Solariella obscura,* 4 juv.; *Margarites costalis,* 26; *M. frigidus,* 4; *Velutina velutina,* 2; *Lepeta caeca,* 2. Amphineurans—*Trachydermon albus,* 2; *Symmetrogephyrus vestitus,* 12. Tunicates—*Amaroucium* sp., 3; *Chelyosoma macleayanum,* 8; *Styela rustica macrenteron,* 8; *Boltenia ovifera,* 31 (host of copepods mentioned above).

STATION 45, in the rubble zone, had a fairly rich fauna, and mollusks were conspicuous in the hauls. Animals: Sponges—*Cioxeamistia* sp. (C); *Echinoclathria beringensis,* 3; *Myxilla incrustans,* 1 lot; *Halichondria lambei* (C). Hydroids—Unidentified calyptoblast (C). Anthozoans—Sea anemones, 22; *Eunephthya rubiformis* (octocoral) (C). Bryozoans—*Eucratea loricata* (C); *Emballotheca stylifera* (C); *Porella minuta* (C); *Mucronella microstoma* (C); *Lichenopora verrucaria* (A); other encrusting forms (A); *Flustrella gigantea* (A). Entoprocts—*Barentsia gorbunovi,* 2. Polychaetes—*Autolytus fallax,* 7. Ophiurans—*Ophiura robusta,* 4. Echinoids—*Strongylocentrotus drobachiensis,* several. Holothurians—*Psolus fabricii,* 26. Cirripedes—*Balanus balanus* (C); *B. rostratus apertus* (C). Amphipods—*Metopella nasuta,* 1; *Stenothoe barrowensis,* n. sp., 2; *Metopelloides tattersalli* (2d record of this species), 1; *Parapleustes*

pulchellus, 1; *Eusirus cuspidatus,* 6; *Melita dentata,* 3; *Guernea nordenskiöldi,* 1; *Ericthonius tolli,* 30. Decapods—*Eualus gaimardi,* 38; *Hyas coarctatus alutaceus,* 3. Pelecypods—*Astarte borealis,* 2; *Cardita crassidens,* 8; *Liocyma becki,* 4. Gastropods—*Admete middendorffiana,* 2; *Ptychatractus occidentalis,* 3; *Neptunea ventricosa,* 2; *Buccinum plectrum,* 6; *B. polare,* 2; *Piliscus commodus,* 6; *Boreotrophon clathratus,* 3; *Natica clausa,* 5; *Polinices pallidus,* 2; *Margarites costalis,* 31. Amphineurans—*Trachydermon albus,* 3; *Symmetrogephyrus vestitus,* 10.

Station 46 was also in the rubble zone. Although common, the encrusting bryozoans were not so abundant at this station as at the following station. Animal life was only fairly abundant: Hydroids—*Lafoeina maxima* (AA). Anthozoans—sea anemones, 8. Nemerteans—*Tetrastemma* sp., several; *Amphiporus pacificus,* 2. Brachiopods—*Diestothyris spitzbergensis,* 7. Bryozoans—*Lichenopora verrucaria* (C); *Alcyonidium polyoum* (C). Polychaetes—*Harmothoë extenuata,* 4; *H. imbricata,* 15. Ophiurans—*Ophiura nodosa,* 1 (the only specimen taken). Echinoids—*Strongylocentrotus drobachiensis,* few (the largest specimens taken). Holothurians—*Psolus fabricii,* 3. Cirripedes—*Balanus crenatus,* few (C). Amphipods—*Onisimus affinis,* 2; *Ampelisca birulai,* 3; *Byblis gaimardii,* A; *Haploops laevis,* 5+; *Ischyrocerus latipes* (C); caprellids (C). Decapods—*Pandalus goniurus,* 2; *Eualus gaimardi* (C); *Pagurus splendescens,* 2; *P. trigonocheirus,* 5; *Hyas coarctatus alutaceus,* 17 (some especially large specimens). Pelecypods—*Astarte borealis,* 2; *A. montagui,* 5. Gastropods—*Neptunea* sp., 4; *N. ventricosa,* 3; *Epitonium greenlandicum,* 2.

Station 47 was in a particularly rich area of the rubble zone. The abundance of its fauna was comparable to that of Stations 20 and 44: Sponges—*Leuconia ananas,* 5+. Hydroids—Unidentified calyptoblast (C); *Lafoeina maxima* (C). Anthozoans—Sea anemones, 15. Turbellarians—*Notoplana atomata,* 9. Nemerteans—*Amphiporus angulatus,* 12; *A. lactifloreus,* 10+; *A. pacificus,* 8+. Sipunculids—*Golfingia margaritacea,* 3. Bryozoans—*Eucratea loricata* (AAA); *Electra crustulenta* (A); *Bidenkapia spitzbergensis* (AA); *Tricellaria erecta* (AA); *Dendrobeania murrayana* (A); *Ragionula rosacea,* several col.; *Pachyegis princeps* (A); *Costazia nordenskjoldi* (A): *Hincksina nigrans* (A); other species encrusting on stones (AA); *Lichenopora verrucaria* (C). Entroprocts—*Barentsia gorbunovi* (A). Polychaetes—*Eunoë nodosa,* 5; *Harmothoë extenuata,* 51; *H. imbricata,* 29; *Pholoë minuta,* 8; *Eteone flava,* 6; *Eumida minuta,* 10; *Autolytus fallax,* 6; *Eusyllis blomstrandi,* 30; *Syllis fas-*

ciata, 20; *Lumbrineris fragilis*, 5; *Lanassa venusta*, 6; *Nicolea venustula*, 7; *Pista maculata*, 6; *Polycirrus medusa*, 12; *Terebellides stroemi*, 7; *Spirorbis spirillum*, 14. Ophiurans—*Amphiodia craterodmeta*, 2. Echinoids—*Strongylocentrotus drobachiensis*, several. Cirripedes—*Balanus crenatus* (adults) (AAAA, young specimens 1-3 mm. long, growing on practically everything). Copepods—*Schizoproctus inflatus*, 7. Amphipods—*Anonyx nugax*, 3; *Byblis gaimardii*, 14+; *Haploops laevis*, 7+; *Gitanopsis arctica*, 4; *Acanthonotozoma serratus*, 15; *Metopa clypeata*, 9; *M. longicornis*, 25; *M. spinicoxa*, n. sp., 30; *Sympleustes uncigerus*, 35; *Eusirus cuspidatus*, 24; *Melita dentata*, 16; *Maera danae*, 8; *Eurystheus melanops*, 9; *Ischyrocerus latipes* (C); *Ericthonius hunteri*, 15. Decapods—*Sclerocrangon boreas*, 4; *Eualus gaimardi*, 165; *Spirontocaris phippsi*, 4; *S. spina*, 2; *Pagurus splendescens*, 14; *P. trigonocheirus*, 13; *Hyas coarctatus alutaceus*, 13. Pelecypods—*Astarte montagui* (A). *Cardita crassidens*, 3; *Hiatella artica* (A). Gastropods—Dorids (white), 3; *Buccinum glaciale*, 6; *B. morchianum*, 2; *Piliscus commodus*, 34; *Natica clausa*, 4; *Margarites costalis*, 8; *M. vahli*, 5; *Oenopota harpa*, 2. Tunicates—*Chelyosoma macleayanum*, 3; *Styela rustica macrenteron*, 4; *Boltenia ovifera* (A); *Molgula griffithsi* (A).

STATION 48 was 2.5 miles from shore, at a depth of 129.5 feet in what would supposedly be the rubble zone, but here the rubble was covered by a mud deposit. A bottom sampler used through a hole in the ice brought up very little except mud. Animals: Amphipods—*Haploops laevis*, 1 female with 90 peach-colored eggs containing embryos in which eye spots and appendages were visible. Pelecypods—*Nuculana minuta*, 2 (1 a dead shell); *Astarte montagui*, 1; *Macoma calcarea*, 1.

STATION 49 was over the rubble zone where mud had been deposited. At a distance of 3.1 miles from shore, holes were made through 6 inches of ice where a lead had frozen over, and a dredge was lowered to the bottom and pulled by a dog team, but the holes were too close together to get sufficient horizontal pull. The dredge brought up some small stones mixed with the mud. Insofar as is possible, a complete list of the animals taken is given below:

Animal	Number	Remarks
Hydroids:		
Lafoeina maxima		Several colonies
Nemerteans:		
Amphiporus imparispinosus	1	
Sipunculids:		
Golfingia margaritacea	1	Small

Animal	Number	Remarks
Bryozoans:		
Eucratea loricata	C	With brown bodies
Alcyonidium polyoum	C	With oocells—orange eggs
Carbasea carbasea	C	Full of brown bodies
Polychaetes:		
Eunoë nodosa	1	
Gattyana cirrosa	1	
Harmothoë extenuata	1	
H. imbricata	3	
Pholoë minuta	1	
Eteone longa	2	
Castalia aphroditoides	1	Regenerating posterior end
Syllis cornuta	2	Epitokous form with swimming setae
Nephtys ciliata ?	1	Very young
Scoloplos armiger	1	
Chaetozone setosa	1	
Ampharete acutifrons	1	
A. goësi	2	
Cirripedes:		
Balanus crenatus	Few	
Amphipods:		
Byblis gaimardii	2	Juveniles under 5 mm.
Ischyrocerus latipes	6	1 ♂, 5 ♀, 1 with developing marsupium
I. commensalis ?	1	Ovigerous ♀, eggs in early stages
Ericthonius tolli	1	Other very small ones in mud nest
Decapods:		
Eualus gaimardi	2	♂♂
Pagurus trigonocheirus	3	small ♂♂
Pelecypods:		
Nucula tenuis	6	1 with empty gonads, others too immature to determine sex
Nuculana minuta	2	Both immature
Yoldia myalis	3	1 with immature eggs, 2 others too immature
Astarte montagui	10	6 appeared to have mature eggs
Hiatella arctica	2	
Gastropods:		
Oenopota harpa	1	

STATION 50, at a distance of 3.2 miles from shore, was also over the rubble zone where mud had been deposited. Holes were made in the lead ice and the dredge was hauled by dog team between holes about 350 feet apart. This was the most successful of the winter dredgings. An attempt has been made to list all the animals collected:

Animal	Number	Remarks
Porifera:		
Unidentified species	1	
Hydroids:		
Syncoryne sp.	1	
Lafoeina maxima	AA	
Anthozoans:		
Burrowing anemones	3	
Nemerteans:		
Micrura alaskensis	1	
Amphiporus imparispinosus	2	
A. lactifloreus	1	
Unidentified sp.	1	
Tetrastemma bicolor	2	
Priapulids:		
Priapulus caudatus	1	
Brachiopods:		
Diestothyris spitzbergensis	13	All living; contained eggs
Hemithyris psittacea	C	Empty shells
Bryozoans:		
Eucratea loricata	C	Full of brown bodies
Carbasea carbasea	4	Some with brown bodies
Tricellaria erecta	3	Eggs and brown bodies in same colony
Dendrobeania murrayana	2	
Costazia nordenskjoldi	4	Apricot-colored eggs
Hincksina nigrans	C	In one colony there were several cells with brown bodies
Other encrusting species	A	Many with brown bodies
Alcyonidium pedunculatum	2	With active sperm
A. polyoum	C	With cells full of sperm
Vesicularia fasciculata, n. sp.	Few	
Polychaetes:		
Arcteobia anticostiensis	2	
Eunoë nodosa	2	
Gattyana cirrosa	2	
Harmothoë extenuata	3	
H. imbricata	4	
Eteone barbata	1	
E. flava	2	
Phyllodoce groenlandica	1	
Autolytus fallax	3	1 ♂ polybostrichus, 2 stem form
A. alexandri	1	
Eusyllis blomstrandi	6	
Exogone naidina	1	
Syllis cornuta	1	Epitokous form with swimming setae
Nephtys ciliata	1	
Glycinde wireni	3	
Lumbrineris fragilis	5	

Animal	Number	Remarks
Scoloplos armiger	4	
Polydora caulleryi	1	
Chaetozone setosa	1	
Brada villosa	1	
Scalibregma inflatum	3	
Praxillella praetermissa	2	
Pectinaria granulata	2	
P. hyperborea	1	
Ampharete goësi	8	
Nicolea venustula	2	
Polycirrus medusa	1	
Terebellides stroemi	13	
Trichobranchus glacialis	5	
Chone infundibuliformis	2	
Spirorbis granulatus	5	
Ophiurans:		
Amphiodia craterodmeta	2	
Holothurians:		
Unidentified sp.	1	
Cirripedes:		
Balanus crenatus	C	
Cumaceans:		
Leucon sp.	1	
Tanaidacids:		
Unidentified sp.	7	
Isopods:		
Phryxus abdominalis	1	
Amphipods:		
Anonyx nugax	2	1 ♀ 38 mm. long
Ampelisca birulai	2	
A. macrocephala	1	
Byblis gaimardii	3	1 young ♀, 2 ovigerous ♀♀ with embryos nearly ready to escape egg cases
Haploops laevis	12	
Maera danae	4	8 mm.
Lembos arcticus	2	
Photis reinhardi	7	1 ovigerous ♀—eggs in early stages
Unciola leucopis	2	1 ♂, 1 ♀
Ischyrocerus latipes	15	7 ♂♂, 8 ♀♀—1 with developing marsupium
Ericthonius hunteri	21	
E. difformis	1	
Dulichia spinosissima	1	♀ 35 mm. long
Caprellid	1	
Decapods:		
Eualus gaimardi	9	
Pagurus trigonocheirus	2	1 small ♂

Animal	Number	Remarks
Pycnogonids:		
Unidentified sp.	2	
Pelecypods:		
Nucula tenuis	8	Gonads immature
Nuculana minuta	2	" "
Yoldia myalis	1	
Astarte montagui	9	1 ♀ filled with mature eggs, 3 immature ♀♀, 1 ♀ with immature eggs, 4 ♂♂ with fairly well-filled testes
Macoma calcarea	1	
Liocyma fluctuosa	1	Shell only
Hiatella arctica	7	Gonads immature; also many small ones 2-3 mm. long on *Lafoeina maxima*
Gastropods:		
Admete middendorffiana	1	
Beringius stimpsoni	1	
Buccinum ciliatum	1	
Piliscus commodus	1	
Natica clausa	3	
Oenopota harpa	1	Apex covered with *Syncoryne* sp.
Tunicates:		
Styela rustica macrenteron	2	Gonads immature
Boltenia echinata	2	" "
B. ovifera	3	" "

STATION 51 was in the rubble zone, 3.1 miles from shore, where a very sticky mud had been deposited. The dredge haul was made by dog team. The following animals were collected: Nemerteans—*Tetrastemma candidum,* 2 (small). Polychaetes—*Gattyana cirrosa,* 1; *Syllis fasciata,* 1; *Scalibregma inflatum,* 1. Amphipods—*Onisimus affinis,* 2; *Byblis gaimardii,* 8; *Haploops laevis,* 1; *Podoceropsis lindhali,* 1 (♂); *Protomedeia fasciata,* 1 (♂); *Ischyrocerus latipes,* 1. Pelecypods—*Macoma calcarea,* 5 (2 ♀♀ with developing eggs, 3 ♂♂ with lively sperm).

STATION 52 was also in the rubble zone where mud had been deposited. It was 4.2 miles from shore. Holes were made through the ice where a lead had frozen over and 6 samples were taken with a bottom sampler. The following animals were collected: Protozoans—Foraminifera (C). Nemerteans—*Amphiporus imparispinosus,* 5. Bryozoans—*Eucratea loricata,* (C) (with brown bodies); *Carbasea carbasea,* few col. (with brown bodies); *Myriozoum subgracile,* small col. Polychaetes—*Scalibregma inflatum,* 1; *Ampharete acutifrons,* 1; *A. goësi,* 1.

Station 53 was undoubtedly in the rubble zone but the small bottom sampler brought up nothing but mud. Numerous holes were made through the ice in a search for rubble bottom that was not covered with mud.

Station 53a was also in the mud-covered rubble zone. A bottom sampler was used and only a few animals were brought up: Amphipods—*Socarnes bidenticulatus,* 1 (juvenile, 6.5 mm.); *Melita formosa,* 1 (♂).

Station 53b was in the mud-covered rubble zone off Browerville (a portion of Barrow Village). It was 2.5 miles from shore. Bottom samples were taken at intervals in a line from Station 53a to 53b about 2.5 miles from shore, in a futile attempt to find an area not covered by mud. The following animals were taken: Polychaetes—*Eteone spetsbergensis,* 1. Amphipods—*Melita formosa,* 1 (♂).

Station 54 was in the true mud zone. Animals: Anthozoans—*Cerianthus* sp., 7. Polychaetes—*Nephtys ciliata,* 5. Pelecypods—*Nucula tenuis,* 3; *Macoma calcarea,* 41.

Station 55 was in the mud-covered rubble zone. The animals taken, especially the *Cerianthus,* indicate that they had reestablished themselves after the disturbance the preceding fall: Anthozoans—*Cerianthus* sp., 30. Pelecypods—*Yoldia hyperborea,* 1; *Macoma calcarea,* 34.

Station 55a was in the mud-covered rubble zone. It yielded few animals, among which were Pelecypods—*Yoldia hyperborea,* 5; *Serripes groenlandicus,* 2.

Station 56 was also in the mud-covered rubble zone. Some of the animals collected there were obviously reestablishing themselves. Anthozoans—*Cerianthus* sp., 5. Pelecypods—*Nucula tenuis,* 3; *Yoldia scissurata,* 1; *Y. hyperborea,* 2; *Serripes groenlandicus,* 3; *Macoma calcarea,* 20.

Station 57 was undoubtedly in the mud-covered rubble zone, though at borderline depths of around 118 feet it would have been difficult during the summer of 1950 to determine whether the station was in the mud zone with stones from the rubble zone deposited there or in the rubble zone with a mud deposit. Some of the animals from this station were: Nemerteans—*Amphiporus lactifloreus,* 8. Bryozoans—*Vesicularia fasciculata,* n. sp., few. Polychaetes—*Chone infundibuliformis,* 5. Amphipods—*Haploops laevis,* 18+. Pelecypods—*Nucula tenuis,* 17; *Yoldia myalis,* 2; *Astarte montagui,* 4; *Macoma calcarea,* 14.

Station 58 was also undoubtedly in the mud-covered rubble zone. Some of the animals, such as *Nucula tenuis,* were obviously trans-

plants. Hydroids—*Tubularia* sp., 3. Pelecypods—*Nucula tenuis,* 14; *Astarte montagui,* 8; *Macoma calcarea,* 15; *M. oneilli,* 2.

STATION 59 was in the mud-covered rubble zone but it yielded a few more animals than some of the above stations. Most of these are listed below: Sponges—*Halichondria lambei* (C). Hydroids—*Lafoeina maxima* (C). Nemerteans—*Cerebratulus fuscus,* 1. Bryozoans—*Electra crustulenta* (C); *Crisia cribraria* (C); *Hincksina nigrans* (C); *Bidenkapia spitzbergensis* var. *alaskensis,* n. var. (C). Polychaetes—*Scalibregma inflatum,* 3; *Terebellides stroemi,* 8; *Chone duneri,* 4. Ophiurans—*Amphiodia craterodmeta,* 5. Copepods—*Choniostoma mirabile,* 3. Amphipods—*Haploops laevis,* 44; *Stegocephalus inflatus,* 1. Decapods—*Eualus gaimardi,* 34.

STATION 61 was in the rubble zone and had been covered with mud. Representative animals from this station were: Nemerteans—*Cerebratulus marginatus,* 1. Amphipods—*Socarnes bidenticulatus,* 3; *Acanthonotozoma serratum,* 2; *Maera danae,* 5. Decapods—*Pagurus trigonocheirus,* 6. Pelecypods—*Yoldia myalis,* 2; *Musculus niger,* 2. Gastropods—*Natica clausa,* 3.

STATION 62 was in the rubble-zone depth and had been covered with mud. Originally it may have been a special area of the rubble zone in which gravel rather than stones predominated, for the dredge brought up only mud and gravel without any stones. A laborious search yielded the following animals: Anthozoans—*Cerianthus* sp., 4. Bryozoans—*Alcyonidium pedunculatum,* 3. Decapods—*Eualus gaimardi,* 8. Pelecypods—*Nucula tenuis,* 7; *Yoldia myalis,* 2; *Musculus corrugatus,* 2; *M. niger,* 2; *Macoma calcarea,* 9. Gastropods—*Aquilonaria turneri,* 1 (a rare species).

The above collecting stations may be located on figure 1. From one to five or six hauls were made at each station. Had it been possible to identify all the specimens, the list for each station would have included other animals.

In addition to the above stations, collections were made at a few other places. For example, on the west side of Elson Lagoon at the entrance to a small tributary lagoon, where the water was about 7 feet deep and was more or less brackish, the following animals were taken on one occasion: Isopods—*Idotaega entomon,* 6. Amphipods—*Gammarus locustus* var. *setosus,* 50; *Gammaracanthus loricatus,* 12; *Pseudalibrotus* sp. (?), hundreds.

TRAPPING THROUGH THE ICE

As soon as the ocean was frozen over a mile or more from shore, several holes 20 inches square were made through the ice with the

ice-cutting device (pl. 2, fig. 2). As freezing continued, more holes were made farther from the shore. In order to retard as much as possible the freezing over of the cut surface, as well as to protect the workers, a quonset-shaped icehouse (pl. 4, fig. 2) approximately 8 by 10 feet was built over each hole, or the hole was covered with squares of insulating material held in place by boards. Despite this protection, ice formed to a depth of about 3 inches between visits. Also, the ice walls of the hole, which ranged from 2 to 8 feet thick, would grow inward as the winter progressed and had to be kept chipped away to keep the hole large enough for working. As the weather moderated during the spring months it was much simpler to cut holes occasionally than to keep the old ones clear.

Several types of traps were tried to determine which were the most efficient for various kinds of animals. Window screen was used for small animals such as amphipods and shrimps. These were made in the form of a cylinder with a funnel leading into one end and a hinged door in the side large enough for a hand to be inserted. Another type was made from an oil drum by removing both ends and putting a funnel of $\frac{1}{4}$-inch hardware cloth in one end and covering the other end with the same material. A door was cut with a torch. Traps for catching fish were made of small-mesh chicken-wire netting, and still others were made of hardware cloth with $\frac{1}{4}$-inch mesh.

Both rectangular and cylindrical traps were used, but the former were much more difficult to pull up through the hole in the ice than the latter, as they would catch on the lower edge of the ice as they were drawn up from the ocean floor. The diameter of the hole at the bottom was usually smaller than at the surface, for it was more difficult to keep the encroaching ice chipped away from the sides at a depth of 7 feet.

Crab traps consisting of large metal rings with netting across the circles were also used. These traps were baited with fish or meat fastened in the center of the netting.

A couple of lath traps, somewhat on the order of lobster traps, were tried, but the laths were too far apart to retain the Arctic cod which were running small at the time this type of trap was tried. Since it was known that Arctic cod feed on amphipods, it was considered desirable to allow some traps to float up under the lower surface of the ice in the hope that cod might find their way into the trap if they were feeding on amphipods on the lower surface of the ice. The method or the traps, or both, were unsuccessful.

If available, some fish or meat scraps were placed in the traps for bait. If this was wrapped in screen or wire netting it was more effec-

tive than if placed loose in the trap. Thus encased it could be fastened to the trap wherever desired.

Holes were made at the following localities, the depths given being the depth of the water from the upper surface of the ice to the ocean bottom: Near shore, at 7 feet; one-half mile from shore, at 21 feet; three-fourths mile or more, at 37 feet; 1.25 miles, at 64 feet; 1.6 miles, at 80 feet; 1.8 miles, at 80 feet. In all instances the bottom was muddy at the depths investigated.

The traps were attached to ropes and lowered to the bottom. When pulling them up for examination, the ice that had formed over the surface of the hole had to be chopped away and dipped out with a sieve-dipper. Then the rope, which had frozen to the side of the ice near the top of the hole, had to be chipped free before the trap could be pulled to the surface. If possible, to prevent the animals from freezing in the air, the trap was examined without withdrawing it entirely from the water, and the specimens were hastily transferred to a large container, such as a 5-gallon thermos jug, for transportation to the laboratory. During the coldest weather the jug had to be wrapped in insulating material to prevent the contents from freezing.

In the following log, unless otherwise stated, the traps were always placed on the bottom.

TABLE 6.—*Log of trapping through ice*

DEPTH 7 FEET. ICE 3 FEET THICK

Date	Trap	Data
1-27-50	Chicken wire	Set today
1-28-50	" "	Nothing
1-30-50	" "	1 medium Arctic cod (*Boreogadus saida* (Lepechin))
1-31-50	" "	Nothing. Removed from hole
	Oil drum	Set today
2- 1-50	" "	1 medium Arctic cod (chicken entrails for bait)
2- 3-50	" "	Nothing
2- 4-50	" "	3 Arctic cod
	Lath	Set today, just under ice
2- 5-50	"	Nothing
	Oil drum	3 Arctic cod
	" "	2 Arctic cod
2- 6-50	Lath "	Nothing (openings too large for small Arctic cod ?)
2- 7-50	Oil drum	6 Arctic cod. The trap was pulled up for inspection at 4 p.m. and contained 4 fish. It was lowered without removing the fish and was inspected again at 9 p.m., at which time it contained 6 fish.

TABLE 6.—*Log of trapping through ice*—continued

Date	Trap	Data
2- 7-50	Oil drum	A large amphipod, *Onisimus affinis,* was found frozen on the ice wall of the hole, evidently brought up with the trap. Bait: chicken entrails plus decayed Arctic cod. A single-mantle Coleman lantern had been burning in the snow house over this hole from 10 a.m. until 9 p.m. Indirect lighting on the hole. Light left on to burn overnight.
	Chicken wire	1 *Onisimus affinis*
2- 8-50	Oil drum	2 Arctic cod (one only 90 mm. long). The light was out at 8:15 a.m.
2- 9-50	" "	1 Arctic cod at 10:00 a.m. Nothing at 6:30 p.m.
	Chicken wire	Set at 10:00 a.m., resting on oil-drum trap. 1 Arctic cod at 6:30 p.m. A light had been burning in snow house from 10:00 a.m. until 6:30 p.m.
2-10-50	Wire mesh	2 Arctic cod
	Oil drum	Nothing at 4:20 p.m.
2-11-50	Wire mesh	4 Arctic cod at 3:45 p.m.
2-15-50	Oil drum and wire mesh	10 Arctic cod, all stomachs empty. Traps had not been pulled for over three days. Measurements, 7.5 to 12.1 cm.
2-24-50	Oil drum	3 Arctic cod
3- 4-50	" "	2 Arctic cod, about 5.0 cm.
	Chicken wire	1 Arctic cod, about 12.0 cm.
3-10-50	Oil drum	1 amphipod, *Dulichia spinosissima* (ovigerous)
		DEPTH 21 FEET
1-27-50	Lath	Set today, unweighted and allowed to float up under the ice, which was 3 feet thick.
1-28-50	"	Nothing. The trap appeared to be frozen to the undersurface of ice.
1-30-50	"	2 species of amphipods; 1 small Arctic cod
1-31-50	"	Nothing. A light bulb and 2 dry-cell batteries, supported to prevent them from rolling around, were placed in a gallon jar, which was fastened inside the trap. The trap was lowered so that the lower end projected into the water below the surface of the ice. The hole was covered with boards and snow.
2- 1-50	Lath	Nothing. Light was almost burned out. Replaced without the light.
2- 3-50	"	2 Arctic cod (1, 103 mm. long, had 4 amphipods, *Rozinante fragilis,* in its stomach). Temperature of the air, —30° F. The fish froze while getting them out of the trap.

TABLE 6.—*Log of trapping through ice*—continued

DEPTH 37 FEET

Date	Trap	Data
1-25-50	Oil drum	1 annelid, *Autolytus fallax* (female sacconereis with egg sac)
1-27-50	" "	Amphipods (around bait)—12 *Anonyx nugax;* 1 *Orchomenella pinguis;* 1 *Tryphosa triangula;* 1 each of 2 other species
1-28-50	" "	Nothing
1-30-50	" "	1 annelid, *Pectinaria hyperborea.* 1 *Anonyx nugax.* 1 small clam
2-24-50	Screen	Two cylindrical window-screen traps set today. No. 1 set at 10 feet, baited with decaying meat; No. 2 set at 20 feet, with 2 pieces of metal foil suspended in it.
2-25-50	Wire mesh	No. 3 (¼-inch mesh) set today on the bottom. Baited with codfish waste.
2-27-50	Screen	No. 1, nothing; No. 2, 6 Arctic cod
	Wire mesh	No. 3, 8 Arctic cod
2-28-50	Screen	*Anonyx nugax* (hundreds of small ones and a few large); 8 Arctic cod
	Wire mesh	10 Arctic cod (fish-tail bait)
	Oil drum	Nothing (chicken entrails for bait)
2- 4-50	Wire mesh	1 small Arctic cod
3- 6-50	Screen	*Anonyx nugax* (few small)
	Wire mesh	1 annelid, *Eteone flava;* 3 Arctic cod; 1 *Lycodalepis polaris* (fish)
3-10-50	Screen	Amphipods—several *Anonyx nugax* (from 10 mm. to adult); 2 *Pseudalibrotus* sp. (1 female, 9 mm. long, with 16 maroon eggs that turned orange in preservative; egg sizes: 599, 632, 648, 664, 762, 782, and 794 microns; 1 female 8 mm. long); 1 *Pleustes panoplus* with eggs in 2-celled stage; 2 *Tryphosa groenlandica;* 2 caprellids. Snails—2 *Buccinum angulosum normale;* 1 *B. angulosum subcostatum*
3-11-50	"	1 jellyfish, *Chrysaora* sp. 1 annelid, *Antinoë sarsi,* 40 mm. long, shed sperm when water temperature increased to that of room. Amphipods—1 *Hyperia medusarum;* 5 of 2 unidentified species; 2 *Ischyrocerus latipes,* 1 male and a female that had just lost its brood of young. 1 snail, *Buccinum angulosum normale.* 5 small sculpins
4-11-50	"	Annelids—1 *Antinoë sarsi;* 2 *Phloë minuta;* 5 *Nephtys ciliata* (?) young
4-27-50	Wire mesh	2 *Lycodalepis polaris* (29.8 cm. and 31 cm. long). One had swallowed an Arctic cod 14 cm. long and the tail was protruding from its mouth

TABLE 6.—*Log of trapping through ice*—continued

Date	Trap	Data
		when it was brought in. There was also an amphipod, *Anonyx nugax,* in the stomach of the *Lycodalepis.*
5- 2-50	Screen	Several annelids. *Anonyx nugax,* common. 2 snails, *Buccinum angulosum subcostatum* and *B. plectrum.* Several Arctic cod (one had swallowed another small one)
5- 9-50	"	1 *Lycodalepis polaris*
5-17-50	"	Several jellyfish, *Cyanea capillata,* in and on trap. Several amphipods, *Anonyx nugax.* Snails—4 *Buccinum angulosum subcostatum;* 5 *B. angulosum normale;* 4 *B. angulosum transliratum*
5-23-50	Crab	4 snails
	Wire mesh	1 snail, *B. angulosum transliratum.* 1 Arctic cod
5-26-50	Screen	1 snail, *B. angulosum transliratum*
5-30-50	"	2 snails, *B. angulosum normale*
6- 6-50	"	1 annelid, *Phyllodace groenlandica.* 1 shrimp, *Eualus gaimardi.* 4 snails—1 *Buccinum angulosum transliratum;* 2 *B. angulosum subcostatum;* 1 *B. angulosum normale*
6- 9-50	"	1 shrimp
6-11-50	"	Hydromedusae—2 *Sarsia flammea;* 15 *Aglantha digitale.* 1 nemertean. Annelids—*Antinoë sarsi;* 9 small *Pholoë minuta.* 1 copepod. 6 small shrimps; 3 *Eualus gaimardi* (2 males, 1 female). 8 pteropods, *Clione limacina*
6-13-50	"	5 snails (same species as above)
6-23-50	"	Amphipods—3 *Weyprechtia heuglini*
		4 pteropods, *Clione limacina*
6-27-50	All traps	Nothing (no bait)
6-30-50	Screen	1 hydromedusa, *Aglantha digitale* (dead). 1 arrow worm, *Sagitta elegans* (dead). 2 annelids, *Phyllodoce groenlandica* (12 to 14 in. long). Several copepods. 1 pteropod, *Clione limacina.* (The trap was baited but the door was missing.)

DEPTH 64 FEET

Date	Trap	Data
4-18-50	Screen	Set today (baited with salmon trimmings)
4-24-50	"	*Anonyx nugax* (exceedingly abundant). Unidentified amphipod (abundant). 1 snail, *Buccinum polare*
4-27-50	"	1 annelid, *Eteone barbata.* 1 shrimp
5-17-50	"	Several jellyfish, *Cyanea capillata.* 2 annelids, *Phyllodoce groenlandica.* *Anonyx nugax*

TABLE 6.—*Log of trapping through ice*—continued

Date	Trap	Data
		(few). 2 *Orchomenella pinguis* (females with maroon eggs; one also had a parasitic copepod in its marsupium). 16 snails—3 *Buccinum polare;* 13 *B. angulosum* (including the typical form and three varieties)
5-30-50	"	1 snail, *B. angulosum* variety

DEPTH 80 FEET, 1.6 MILES FROM SHORE

Date	Trap	Data
3- 6-50	Wire	Set today
3- 8-50	Screen	1 hydromedusa, *Halitholus cirratus.* 1 small unidentified amphipod
3- 9-50	Wire	1 *Halitholus cirratus. Anonyx nugax* (abundant). 3 shrimps. 1 crab, *Hyas coarctatus alutaceus*
3-11-50	Screen	*Anonyx nugax* (few). 1 hermit crab, *Pagurus trigonocheirus* (female). 1 Arctic cod
	Wire	7 Arctic cod (trap suspended 7 feet down in water)
3-13-50	Screen	*Anonyx nugax* (few). 1 *Dulichia spinosissima* (amphipod). 1 small shrimp
3-14-50	"	*Anonyx nugax* (abundant). 9 shrimps, *Eualus gaimardi* (8 with developing eggs showing through as green masses)
3-17-50	"	1 amphipod, *Macra danae* (female, 18 mm.). 2 shrimps, *Eualus gaimardi* (with green eggs showing through integument)
3-19-50	"	1 small sculpin (37 mm. long)
3-20-50	"	1 ctenophore, *Beroë cucumis.* 1 nemertean, *Amphiporus lactifloreus.* 7 amphipods, *Hyperia medusarum* (1 ovigerous female, 3 immature females, 3 adult females). 3 snails—1 *Buccinum polare;* 2 *B. angulosum transliratum*
3-29-50	"	Amphipods—1 *Monoculodes borealis;* 1 *Acerodes latipes*
4- 7-50	"	Nothing. Strong northeast winds for several days had altered ice conditions at this station. Ice house caved in.
4-15-50	"	1 shrimp, *Eualus gaimardi* (with green eggs showing through integument)
5-23-50	"	Nothing in trap. Several jellyfish, *Cyanea capillata,* on surface of water at this hole.

DEPTH 80 FEET, 1.8 MILES FROM SHORE

Date	Trap	Data
3-17-50	Wire	2 amphipods, *Socarnes bidenticulatus* (young)
3-20-50	"	1 snail, *Buccinum polare* (large). Amphipods—6 *Hyperia galba.*

Table 6.—*Log of trapping through ice*—continued

Date	Trap	Data
4-11-50	Screen	Set today, baited with snail viscera and old fish. Great amount of debris in water for the first time since summer.
4-12-50	"	1 jellyfish, *Cyanea capillata* (large). 1 annelid, *Phyllodoce groenlandica. Anonyx nugax* (abundant). 1 snail, *Buccinum glaciale*
	Wire	7 Arctic cod about 50 mm. long (trap suspended at a depth of 10 feet)
4-15-50	Screen	1 *Cyanea capillata.* Amphipods—1 *Anonyx nugax; 2 Orchomenella minuta; 3 O. pinguis; 2 Monoculodes packardi; 1 Ischyrocerus latipes.* 2 shrimps, *Eualus gaimardi* (with green eggs showing through carapace). 1 small clam
4-18-50	"	2 *Cyanea capillata.* Amphipods—*Anonyx nugax* (common); 3 *Orchomenella* ? sp.; 1 *Ericthonius* sp.; 1 *Ischyrocerus* ? sp. 1 snail, *Buccinum tenue*
4-24-50	"	26 unidentified amphipods (9 ovigerous)
5- 2-50	Crab	4 *Cyanea capillata*
5-17-50	Wire	30 Arctic cod (trap suspended at a depth of 10 feet)
5-23-50	"	12 Arctic cod (2 very young) (trap suspended as above)
5-26-50	"	21 Arctic cod (trap suspended as above)
5-30-50	Screen and wire	25 Arctic cod. Traps suspended at a depth of 10 feet in a crack that developed in the ice near the 80-foot hole.

RECORDS OF SURF CONDITIONS AND SHORE COLLECTING

During the summer of 1948 the pack ice did not go more than 10 miles offshore, and except when fog prevented was nearly always in sight. With the exception of one day, drift ice was always in sight. On some days it was scattered, and on others it formed large compact cakes, which often grounded along the shore. Sometimes the floes consisted of masses of small ice cakes and sometimes there were islands of ice several acres in extent (pl. 6, fig. 2). Because of so much floating ice, there was comparatively little surf during the summer of 1948, and as a result very few animals were washed ashore. The writer has never seen a beach so barren of animal life over a 3-month period as was that at Point Barrow during the open water of that year. One specimen of the annelid *Arenicola glacialis* found at the edge of the water, an empty snail shell found near the Point, and a few fragments of dead bryozoan colonies constituted the total flotsam and jetsam for the summer.

In contrast, during the summers of 1949 and 1950 the ice went so far out to sea that it was not seen during the entire season. As a result, during heavy offshore winds strong upwelling took place alongshore, bringing up animals from deeper water, as well as throwing ashore animals that were washed out of the mud at shallow depths by the heavy surf.

In the following, the first three paragraphs are samples of 1948 records.

9-24-48 A wind blowing slightly north of east blew all night last night and all day today. Despite the wind, the ice is coming in toward shore. Moisture freezing in the air this morning.

9-27-48 A strong offshore wind, causing the surface water to move seaward and the lower water to upwell. This brought deeper-dwelling animals near the surface and near shore. By walking out on a grounded ice cake it was possible to dip up several animals from a depth of about 3 feet: Two octopuses of a species of *Cirriteuthis,* 4 *Boreomysis nobilis,* 2 species of chaetognaths, a few annelid worms, and jellyfishes of the genera *Cyanea* and *Aurelia. Cyanea* was very abundant. From one ice cake it was possible to count 39 *Cyanea,* from another 42, and from another 56. A plankton net thrown from the ice cake and simply drawn in yielded a rich haul. There was no surf and no animals were thrown ashore.

9-28-48 The wind has blown steadily for two days from the northeast and the water has become steadily rougher, but with ice cakes grounded alongshore and more in the water offshore no animals washed ashore even though the water was agitated sufficiently to make it impossible to see any animals except jellyfishes in the water.

7-20-49 The pressure ridge went out some time during the night of 7-18-49. The first animals appeared on the beach this morning. They were still alive in pools in the gravel where they had been washed by the surf:

	Sarsia flammea	Few
	Chrysaora sp.	1 (observed offshore)
	Cyanea capillata	10 collected. Small. Large numbers in water alongshore
	Hyperia medusarum	2
	Pseudalibrotus litoralis	6
	Idotaega entomon	1 (with young ready to be released)
	Pycnogonid	1
7-22-49	*Sarsia princeps*	1
	Beroë cucumis	1

7-23-49 Morning: Five or six *Beroë cucumis* for every 10 feet of shore. Arrow worms in water.
Evening: Many *Hyperia medusarum* and 3 pycnogonids.

7-24-49 Evening: *Sarsia princeps* and *Sarsia flammea* so abundant in the

water alongshore and in pools in the gravel that the water was like soup.

Cyanea capillata	Many
Beroë cucumis	1
Hyperia medusarum	Common
Pagurus splendescens	1

7-26-49 Water lapping shore. Bottoms of puddles in the gravel near shore covered over with two species of medusae.

Sarsia flammea	Immense numbers in water alongshore
Sarsia princeps	Abundant
Cyanea capillata	Abundant
Unidentified medusa	Abundant
Beroë cucumis	Few
Pseudalibrotus litoralis	2
Acerodes latipes	1

None of the above animals so plentiful as on 7-24-49.

7-27-49 Morning:

Sarsia species and other medusae	Much reduced in numbers
Cyanea capillata	2
Beroë cucumis	2 (plentiful in evening)
Arrow worms	Small numbers

7-28-49 Water very calm and clear. Above medusae much less abundant than on 7-26-49.

7-29-49 Heavy surf. Ice cakes being grounded ashore. Water muddy from the surf and grounding ice cakes. No planktonic animals visible from shore because of the muddy and agitated condition of the water.

Evening: Ice broken from floe in tiny to large pieces so that it was difficult to get a water sample. Surf still heavier at 11 p.m.

7-30-49 Surf still heavy.

7-31-49 Surf still heavy. Water very murky. Impossible to see animals in the water because of agitation and murkiness. Few fragments of algae washed ashore, with a bryozoan and a species of *Spirorbis* on it.

8- 1-49 Surf still heavy and water very muddy. No animals visible. Algal fragments on beach and also several dead isopods, *Idotaega entomon*.

8- 2-49 Morning: Surf very much moderated. Water clear. No animals noted.

Evening: Swells, light surf. Water clear. Small school of capelin (*Mallotus catervarius*) alongshore. Ten to twenty came up with small wave and went back with the surge. A few maintained positions in the water when the surf surged back. Later in the evening many eggs were noted high on the beach above the present water level as well as below the surge line. Some of the egg masses were buried in the gravel to a depth of several inches. The eggs were attached to the gravel.

8- 3-49	Morning: Surf heavier again. Water murky. No animals seen alongshore.
	Evening: Heavy swells. Water churning. One amphipod collected.
8- 4-49	Morning: Light surf. Water clear. No animals seen.
	Evening: Medium light surf. Water clear. No animals seen.
8- 5-49	Evening: Medium light surf (9 p.m.). Water clear. Capelin observed flipping out of the water about 20 feet from shore. By 9:45 they were close enough to the shore to catch them with a hand net. By 10 p.m. large numbers of gulls were seen on and about the water from near the village to the base.
8- 6-49	Morning: Water clear. No animals seen.
	Evening: Medium heavy surf. Water clear. A few amphipods observed on the beach above the breaking surf.
8-11-49 to 8-15-49	Heavy surf. No animals visible from the shore. A few jellyfishes, *Cyanea capillata*, were washed ashore.
8-17-49	Water fairly calm. Hundreds of small *Cyanea capillata* in water offshore, *Halistaura cellularia* common but less abundant than above species, and small medusae were visible.
8-19-49	Water fairly calm. Small *Cyanea* seen near the Point.
8-21-49	Very heavy surf. A 25-mile northeast wind. A few animals, such as *Arenicola glacialis* and *Antinoë sarsi*, and several amphipods, *Monoculodes borealis, M. schneideri, Gammarus locustus* var. *setosus, Weyprechtia heuglini, Melita formosa, Protomedeia fasciata*, and *P. stephenseni*, n. sp., were on the beach.
8-22-49	Very high surf alongshore. It cut the beach back 40 feet and the boat had to be moved farther back on shore.
8-23-49	Since 8-21-49 a series of spits have been moving along the beach toward the southwest, forming eight projecting lobes in a distance of about 1.5 miles. The lobe near the boat moved down the beach, that is, southwest, a distance of 190 feet and the extension into the sea is 75 feet from the normal shoreline. The movement of these lobes or scallops is easily accounted for—the breakers have been curling against the beach at an angle of about 60 degrees from the perpendicular to the beach line.
8-24-49	Still very stormy. High wind and fairly heavy surf. Colder air. Wind in the same direction for four days. The storm washed various animals ashore, chief among which were amphipods. These formed a continuous line along the beach where they were left by the surf:

Lafoeina maxima	2 colonies
Burrowing anemone	1
Arenicola glacialis	Common
Antinoë sarsi	Few
Melaenis loveni	Few
Cumacean	1
Hyperia medusarum	1
Themisto libellula	2 young females
Onisimus affinis	1 female with embryos
Acanthostepheia behringiensis	4 females, 5 males, 2 immature females

Weyprechtia heuglini	1 male
Melita formosa	Abundant, forming the major portion of the line along the beach
Ischyrocerus latipes	8 females, 1 male
Dulichia spinosissima	3 males
Idotaega entomon	Few
I. sabini	Few
Pagurus splendescens	1 medium male
P. trigonocheirus	2 small males, 1 small female
Unidentified tectibranch	1
Egg collar of *Natica*	1
Mya japonica	1
M. truncata	3
Hiatella arctica	Few
Alcyonidium disciforme	Common, with snail eggs attached
Fishes	Two or three kinds of young

8-25-49 Surf moderating. Long swells from around the Point. Wind decreasing. One large cumacean on shore.

8-27-49 Heavy surf. Still windy and overcast.

8-28-49 Afternoon: Water fairly calm. Along approximately 2 miles of beach only 6 *Arenicola glacialis,* a few fragments of egg collars of *Polinices,* and several *Hiatella arctica* and a few shells of *Macoma calcarea* were picked up.

8-29-49 High surf. Wind again after the calm of yesterday. The following animals were washed ashore:

Cerianthus sp.	1 about 6 inches long
Sand anemone	1
Hamingia arctica	1
Echiurus echiurus alaskanus	Hundreds
Antinoë sarsi	1
Myriotrochus rincki	6
Melita formosa	Few
Pagurus trigonocheirus	1 small
Egg collars of *Polinices*	Several
Serripes groenlandicus	Few
Hiatella arctica	Few

Note that although there was heavy surf preceding and on 8-24-49 and again on 8-29-49, over twice as many species were washed ashore on 8-24-49 as on 8-29-49, but the total number of animals washed ashore on 8-29-49 was much greater than on 8-24-49. Practically all those washed ashore on 8-24-49 were surface dwellers, whereas over half of the species and the majority, numerically, of those washed ashore on 8-29-49 were mud dwellers, indicating that the bottom not only was disturbed more on 8-29-49 than on 8-24-49 but that it was disturbed at a greater distance from shore.

9- 6-49 Medium light surf. Small waves coming onto the shore. A gentle north wind. The phronimid *Themisto libellula* was common along the beach above high-water mark. Most of these amphipods were covered with a thin layer of frost but they began swimming when placed in water. A few *Arenicola glacialis* and a few pycnogonids were on the beach in the evening.

9- 9-49 Morning: Surf very light; small waves coming in irregularly. A gentle east wind. *Themisto libellula* much more abundant than on 9-6-49, forming a streak about a foot in width along the beach. Pycnogonids and the amphipod *Melita formosa* were common.

9-12-49 Above the high water mark there were three rows of *Themisto libellula* extending along the beach, the first about 4 feet above the water line, the second about 6 feet, and the third about 15 feet. The amphipods were abundant in the first two rows, but the highest row was so thick with amphipods that they could be scooped up in great masses with the hands. All the depressions in the gravel were filled with the animals. At random spots in the top row a segment 10 cm. long was marked off and the amphipods contained therein were counted.

Size of segment of row	*Number of amphipods*
10 x 37 cm.	111
10 x 38 cm.	56
10 x 56 cm.	103
10 x 29 cm.	136
10 x 32 cm.	89
10 x 26 cm.	135
10 x 27 cm.	142
10 x 33 cm.	140
10 x 29 cm.	275
10 x 54 cm.	716
10 x 50 cm.	679

In and around the masses of phronimids along approximately three-fourths of a mile of beach, the following animals were found:

Lafoeina maxima	Common
Sand anemone	2 fragments
Cerianthus sp.	1
Sea anemone	3
Echiurus echiurus alaskanus	3
Arenicola glacialis	Few
Harmothoë imbricata	3
Phyllodoce groenlandica	3
Melita formosa	Common
Gammaracanthus loricatus	1 male, 1 female
Dulichia spinosissima	1
D. arctica	1
Caprellids	2 species
Idotaega entomon	Several
I. sabini	Several
Sclerocrangon boreas	1 ovigerous female
Pagurus trigonocheirus	Few
Pycnogonids	14 (3 species)
Tectibranch	1
Dendronotus frondosus	1
Buccinum sp.	Several
Boreotrophon pacificus ?	9 shells

Natica clausa	2
Egg collars of *Polinices*	Several
Velutina plicatilis	2
V. lanigera	1
Macoma calcarea	Few
Mya japonica	1 small

9-13-49 The major portion of the *Themisto libellula* are still alive.

9-14-49 All the *Themisto* are dead. Three badly battered *Echiurus* were on the beach at noon, also 11 male and one female capelin, dead.

9-15-49 Morning: A thin line of *Themisto libellula* along the beach about 2 feet above the water line, and with them a few *Melita formosa.* A few *Cyanea* of the whitish type were in the water.

9-18-49 Afternoon: Waves scouring the beach. A good deal of sediment in the water.

9-19-49 Morning: Sediment in the water. A few *Melita formosa* on the beach, alive.

Evening: A heavy surf scouring the beach. Water cloudy with sediment. Many animals were being washed ashore:

Antinoë sarsi	Few to common
Arenicola glacialis	4
Themisto libellula	Common
Anonyx nugax	Common
Melita formosa	Few to common
Unidentified amphipod	4
Idotaega entomon	Rare
I. sabini	Rare to few
Pagurus splendescens	2 large
P. trigonocheirus	Few, small
Natica clausa	1
Arctic cod	Few (2 very young)
Fish, unidentified	1

Twenty-five different animals were washed ashore on 9-12-49 and 13 species on 9-19-49. Of these 13 species only six duplicated the ones found on 9-12-49.

9-20-49 Morning: Surf medium heavy. Still scouring the beach and washing well up on the beach. With the exception of *Themisto libellula,* which form a thin line along the beach, fewer animals were washed ashore than on the night of 9-19-49. The phronimids are still alive and each large wave washes more ashore.

Medusae	Few, small
Antinoë sarsi	Few
Phyllodoce groenlandica	1
Arenicola glacialis	1
Themisto libellula	Abundant
Acerodes latipes	1
Gammarus locustus var. *setosus*	1
Anonyx nugax	Few

Caprellids	2 (2 species)
Idotaega entomon	2 (one with very early eggs)
I. sabini	Rare
Unidentified tectibranch	1
Dendronotus frondosus	1
Arctic cod	12 (one very young)

9-22-49 Morning and afternoon: Surf medium light, with small swells. Great amount of sediment in water. Gravel thrown up on beach. Animals alongshore less numerous and less conspicuous.

Myriotrochus rinki	1
Antinoë sarsi	Most abundant animal alongshore
Brada villosa	22
Arenicola glacialis	2
Mysis oculata	1 immature female
Themisto libellula	Rare
Anonyx nugax	Few
Monoculodes borealis	7
Protomedeia stephenseni	1
Melita dentata	1
M. formosa	Few (3 ovigerous females)
Cumaceans	4
Arctic cod	4 young
Capelin	3 (1 alive)
Lycodalepis polaris	1 (alive)

9-23-49 Morning: surf medium light, but heavier than yesterday. Waves of a short period. Much sediment. A bank of gravel built up on the beach.

Arenicola glacialis	Abundant. Some being washed in with each wave. Some completely buried by the washed-in gravel.
Themisto libellula	Rare
Anonyx nugax	5
Melita formosa	Few
Unidentified amphipods	2 (2 species)
Cumacean	1

Evening: Surf becoming much rougher.

Antinoë sarsi	1
Arenicola glacialis	Common, but not so plentiful as this morning
Hyperoche medusarum	1
Themisto libellula	Rare
Anonyx nugax	Common
Acanthostepheia behringiensis	2
Melita formosa	Common
Caprellid	1 large
Snail	1 small
Clams	Few small

9-24-49 Morning: Surf heavier than last night. Waves sweeping shore with great speed. Water very turbid. Gravel bank still present but much reduced in height.

Lafoeina maxima	2 colonies
Echiurus echiurus alaskanus	1 (minus its proboscis)
Eucratea loricata	1 large colony (with caprellids)
Antinoë sarsi	Several
Arenicola glacialis	Few
Themisto libellula	Rare
Anonyx nugax	1
Gammaracanthus loricatus	1
Melita formosa	Few
Caprellids	Abundant (3 species)
Idotaega entomon	Rare (dead)
I. sabini	1
Egg collars of *Polinices*	Few
Mass of snail eggs	1, unidentified

9-26-49 Morning: Surf still relatively heavy, but somewhat moderated. Water turbid. Big swells and whitecaps not so prevalent. Three lines extending along the beach, formed largely by the amphipod *Melita formosa.*

Halitholus cirratus	1
Lafoeina maxima	Few
Corymorpha sp.	4
Sand anemone	3
Sand anemone (sp. 2)	Common
Notoplana atomata	3
Nemerteans	2
Echiurus echiurus alaskanus	2
Eucratea loricata	Few (with caprellids)
Alcyonidium polyoum	1
Antinoë sarsi	Common
Melaenis loveni	Few
Phyllodoce groenlandica	Rare
Arenicola glacialis	Rare
Pectinaria granulata	Few
Brada villosa	Few
Myriotrochus rinki	Abundant
Thysanoëssa longipes	Few
Themisto libellula	Rare
Anonyx nugax	1
Pontoporeia femorata	1 male, 2 females
Acanthostepheia behringiensis	4
Paramphithoë polyacantha	1
Atylus carinatus	1
Melita formosa	Extremely abundant
Caprellids	2 species
Idotaega entomon	Rare (some young specimens)
I. sabini	Rare

Pycnogonids	Few
Egg collars of *Polinices*	Few (some with other egg masses attached)
Alcyonidium disciforme	Common
Tunicate (sp. 1)	Few to common
Tunicate (sp. 2)	Rare

9-27-49 Morning: Surf medium, choppy. Water turbid.
Evening: Surf heavier. Long swells. Surface water current moving southward.

9-28-49 Morning: Surf medium heavy. Short-period waves. Coarse gravel building up on beach. Steep bank forming. Surface water current moving southward.

Eunephthya rubiformis	1
Sea anemone	1 small
Echiurus echiurus alaskanus	Common
Halicryptus spinulosus	1
Alcyonidium disciforme	Common
Myriotrochus rinki	Few
Antinoë sarsi	1
Melaenis lovéni	1
Arenicola glacialis	Few
Flabelligera affinis	3
Hyperoche medusarum	1
Acanthostepheia behringiensis	1
Atylus carinatus	2
Gammaracanthus loricatus	1
Melita formosa	Common
Caprellids	Common (2 species)
Idotaego sabini	2 large, few small
Pycnogonids	Few
Coryphella salmonacea	1
Dendronotus frondosus	2
Dendronotus sp.	1 (translucent white)
Egg collars of *Polinices*	Fragments
Gastropod eggs on *Alcyonidium*	Few
Tunicate (sp. 1)	Common
Tunicate (sp. 2)	Few
Arctic cod	3 (one young)
Fish	1 small

9-29-49 Morning: Surf medium light. Water turbid but relatively smooth. Steep bank next to surf line. Evening: Small medusae washed on shore.

9-30-49 Morning: Surf light. Water smooth, clear. Very small swells parallel to shoreline. Very slight wind. The following animals were in the water near shore:

Small medusae	Abundant
Cyanea capillata	1
Beroë cucumis	3
Mertensia ovum	Abundant

10- 4-49 Medium heavy surf. Swells coming in from the southwest. Beach now flat. Water turbid.

Cyanea capillata	Few
Burrowing anemone	1
Sea anemone	1
Echiurus echiurus alaskanus	Large numbers, with many detached proboscides lying on the beach
Melaenis lovéni	1
Anonyx nugax	1
Acanthostepheia behringiensis	1
Gammaracanthus loricatus	2
Melita formosa	Few
Idotaega entomon	Few
I. sabini	1
Pagurus splendescens	2 males
Dendronotus frondosus	2
Egg collars of *Polinices*	1 fragment

10-10-49 Morning: Long swells coming in with a 4- to 5-second period between waves. Waves high but were not destructive when they broke. Mist rising from water. Impossible to see more than 150 feet from shore. Air temperature, 9° F.; water temperature, —0.8° C. Where the surf had come up on shore during the night the water had frozen, forming a strip of ice about 10 feet wide along the beach.

10-12-49 A few *Themisto libellula* washed ashore during the night.

10-17-49 Light surf with small, short-period swells. Water calm and smooth. No wind. At 9:15 a.m. a thin coating of ice was on the ocean out to about 150 feet. Ice alongshore from freezing water from surf. A small ice ledge has started to form alongshore. The following animals had washed ashore:

Corymorpha sp.	7
Echiurus echiurus alaskanus	Abundant
Hamingia arctica	2
Alcyonidium disciforme	Common
Antinoë sarsi	Common
Melaenis lovéni	Abundant
Travisia carnea	6
Arenicola glacialis	Common
Crossaster papposus	1 male, 3 others
Leptasterias polaris forma *acervata*	1
Myriotrochus rinki	Abundant
Themisto libellula	Few
Sclerocrangon boreas	1 large
Aldisa zetlandica (?)	1
Snail egg capsules	4 different species

10-17-49 On beach of small bay near the Point (see *F*, fig. 1).

Cyanea capillata	Common
Echiurus echiurus alaskanus	Abundant

Antinoë sarsi	Common, large
Eunoë clarki	2
Crossaster papposus	5
Leptasterias polaris forma *acervata*	8 large
L. arctica	1
Henricia sanguinolenta	1
Solaster endeca	5
Anonyx nugax	1
Clione limacina	Very abundant, in puddles on the shore and in water offshore
Snail egg capsules	Common
Tunicate	1

10-28-49 The following animals were washed ashore on the beach at the base (*Lafoeina, Eucratea,* and *Psolus* are from the rubble zone):

Lafoeina maxima	Common
Eucratea loricata	1 colony, with eggs of an eolid attached
Alcyonidium disciforme	Few
Psolus chitinoides	1
Dulichia spinosissima	1
Caprellid	1 large
Egg collar of *Polinices*	1 with mass of snail eggs attached
Mya truncata	1 shell

11- 4-49 The following animals, all frozen, were on the shore this morning:

Lafoeina maxima	Few
Eunephthya rubiformis	1
Stomphia coccinea	3
Cyanea capillata	Common
Echiurus echiurus alaskanus	Common
Alcyonidium disciforme	Few
Themisto libellula	2
Melita formosa	1
Idotaega entomon	3
I. sabini	2
Pagurus splendescens	3
Aldisa zetlandica (?)	1
Egg capsule masses, of snails	Few
Tunicate (sp. 1)	1
Tunicate (sp. 2)	2

11-17-49 Afternoon (2 p.m.): Ice cakes grounding and building up. Some had been thrown ashore and piled up during the night. Some freshly frozen blue-green ice on the shore. Water between the ice cakes frozen from 3 to 5 inches thick. Leads still present. Open water a mile from shore.

11-19-49 A lead has developed along the shore and extends southward. Ice floes in some areas are being pushed out to sea again. A 43-mile-an-hour northeast wind is blowing. In the lead two or three different kinds of medusae were floating southward. A fragment of

Beroë cucumis was seen, and a specimen of *Chrysaora* was taken. It contained well-developed eggs and many planulae. Two male *Hyperoche medusarum* were attached to the jellyfish. A duck was surface diving in the lead.

11-20-49 Some of the ice is moving slightly in the direction of the village and the lead of yesterday is narrowing. Most of the lead water now has approximately 1 inch of ice on it and elsewhere the ice is about 11 inches thick. Two or three species of amphipods were collected when the ice was broken through. Thirty or forty ducks were swimming in water that had a thin crust of ice on it.

12- 2-49 The last eider ducks were seen today. The ocean was late in freezing over.

8-10-50 The following animals were found on the beach:

Travisia carnea	4
Crossaster papposus	1
Myriotrochus rinki	Common

8-16-50 *Cyanea capillata* (up to 12 inches in diameter) abundant. No commensal amphipods noted.

8-23-50 The following animals were found on the beach:

Alcyonidium disciforme	Abundant
Melita formosa	Abundant
Idotaega entomon	Few
Serripes groenlandicus	Few
Hiatella arctica	Few
Egg collars of *Polinices*	Common
Rhizomolgula globularis	Abundant (up to 20 mm. in diameter)
Tunicate (sp. 1)	Few

8-24-50 A few *Echiurus echiurus alaskanus* and a few *Arenicola glacialis.*

8-28-50 The isopod *Idotaega sabini* abundant. Examined 26—all females, none ovigerous.

8-29-50 One ctenophore, *Beroë cucumis.*

9- 1-50 A few jellyfishes, *Chrysaora* sp.

ANALYSIS OF PLANKTON SAMPLING

To obtain a complete picture of the plankton situation would require more time than has already been given to the entire investigation of the invertebrate fauna. Also, such a project should be carried on both summer and winter for not less than three years. The staff connected with this investigation was not large enough to give plankton the attention it deserved. However, many pages of notes were accumulated covering the plankton sampling. Although they are too extensive to be included in full here, certain conclusions can be drawn from them, and much information from them will be found under the discussion of the different phyla.

For instance, there is evidence pointing to a cyclical abundance of

diatoms overlapped by a cyclical abundance of larval forms and copepods. This does not show up very pronouncedly in the notes, for the investigation of plankton was always secondary to that of the larger animals and the invertebrate fauna of the bottom. The 1950 winter plankton station was 1.6 miles from shore where the water was 80 feet deep. During January, February, and March the diatoms obtained must of necessity have been ones that were living under the ice or had been carried in by currents from the open leads at least 4 miles farther offshore. There were very few during these three months, but in April they began to increase in numbers. Whether this was due to an increase in light under the ice as the sun rose higher in the sky is not known. When the ice went out in July the cyclical phenomenon began. Great abundance followed by decreasing numbers appeared to take place at about 30- to 40-day intervals during the open season and lengthened to 40 or 50 days in the fall. But several years of sampling would be necessary to establish the certainty of the cycle and the interval. Within one to two weeks following the very abundant flowering of the diatoms, the zooplankton became much more abundant.

There has always been some difference of opinion among oceanographers as to the reason for the diatom cycles in all regions where oceanographic plankton investigations have been carried on. Some maintain that these cycles are caused by a fluctuation in the supply of nutrients—particularly silicates, phosphates, and nitrates—needed by the diatoms; when these nutrients are exhausted the diatoms decrease in number and when the ocean renews them, the diatoms flower again. Others believe that the cycles are due to the increase of zooplankton, made possible by the presence of diatoms, and that the feeding of these hordes depletes the diatom pastures, and the lack of sufficient food in turn depletes the zooplankton. The writer is inclined to think that both factors have their effects; certainly the feeding cycle is a known phenomenon, and there is convincing evidence that it occurs in the Arctic as well as in other oceans.

In the lists below particular attention is given to the young stages of such animals as jellyfishes and ctenophores, to copepods, to the larval forms of other groups, and especially to the winter plankton tows.

Copepods, nauplii, and chaetognaths were the most abundant of the smaller planktonic animals. Any one of these or any combination of these might be so abundant in the material from a plankton tow that it was difficult to sort out the other material. In using the terms "abundant," "very abundant," and "common," the comparison is made

more within the group than with other groups. For instance, it is stated that veligers were very abundant on September 9, 1949, and that copepods were also very abundant on that day, but the number of copepods taken were many times more numerous than the veligers. However, in comparison with the number of veligers taken on other days, on September 9, 1949, they were very abundant.

The tows made in November 1949 were from ice cakes alongshore. Conditions during the latter part of November and during December prevented taking plankton samples. The tows from January 21 to February 28, 1950, inclusive, were vertical ones made through the ice at a distance of three-fourths mile from shore where the water was 37 feet deep. Subsequent tows were made through the ice at the regular plankton station 1.6 miles from shore where the water was 80 feet deep. (See "Plankton Sampling, Winter.")

In the following lists certain abbreviations are used: *Cyanea* refers to *C. capillata: Aglantha* to *A. digitale; Mertensia* to *M. ovum; Beroë* to *B. cucumis; Clione* to *C. limacina;* and *Spiratella* to *S. helicina.* A=abundant; AA=very abundant; AAA=exceedingly abundant; C=common; R=rare; lg.=large; sev.=several; sm.=small; and yg.=young.

TABLE 7.—*Gross analysis of plankton, Point Barrow, Alaska, August-September 1948, September 1949-July 1950*

DIATOMS

8- 2-48	Few of several kinds
8-30-48	Many kinds abundant; circular (*Coscinodiscus*) type, A
9- 4-48	A
9- 9-49	Several kinds, C
9-10-49	AAA
9-13-49	AAA
9-30-49	R
10-24-49	AAA
10-31-49	Few, mostly circular type
11- 1-49	Spiny type, A; spicule type, C; circular type, R-C
11-10-49	Rare
1-21-50	1 fragment of spiny type
1-25-50	Few of circular iridescent type
1-27-50	" " " " "
2-10-50	" " " " "
2-25-50	None
2-28-50	1 circular type
3- 8-50	1 of circular iridescent type
3-14-50	None
3-23-50	2 of circular iridescent type; 1 spiny type

TABLE 7.—*Gross analysis of plankton, Point Barrow, Alaska, August-September 1948, September 1949-July 1950*—continued

3-29-50	Circular iridescent type, few
4- 8-50	Circular iridescent type, R; chain type (sev. kinds), A
4-24-50	1 circular; 1 circular iridescent; 1 chain type (sm., elongate)
5- 2-50	Chain type, A; circular iridescent, C; spiny type, 8
5- 9-50	Circular iridescent type, 7; chain type, 3; 2d chain type, 1
5-17-50	Circular iridescent type, 2; spiny type, 2; chain type, 1; 2d chain type, C
5-23-50	Circular iridescent, 4; spiny type, 2; chain type, 6; 2d chain type, C.
6- 6-50	Chain type, AA
6-20-50	Chain type (sev. kinds), A
6-23-50	Chain type, C
6-27-50	Chain type, C-R
6-30-50	Chain type, few
7-13-50	Circular iridescent, C

COELENTERATES

8- 6-48	5 *Rathkea octopunctata*, budding; medusae of *Obelia*, C
8- 9-48	*Aglantha* in all sizes; 1 medusa of *Obelia;* 1 *Rathkea*, budding
8-12-48	1 sm. *Cyanea;* 1 sm. *Aurelia*
8-16-48	Ephyra of *Cyanea*
9- 4-48	Medusae of *Obelia*, C
9- 9-49	Yg. *Aglantha*, few
1-21-50	None
1-25-50	*Aglantha*, C
1-27-50	" "
2-10-50	None
2-25-50	"
2-28-50	"
3- 8-50	1 sm. *Aglantha*
3-14-50	None
3-23-50	"
3-29-50	*Aglantha*, C (1 with developing gonads)
4- 8-50	10 *Aglantha* (with developing gonads)
4-15-50	1 sm. medusa
4-24-50	2 *Aglantha;* 1 hydromedusa
5- 2-50	7 *Aglantha*
5- 9-50	*Aglantha*, C
5-17-50	3 *Aglantha* (gonads developing)
5-23-50	None
5-30-50	1 *Aglantha;* 1 hydromedusa
6- 6-50	None
6- 9-50	"
6-16-50	"
6-20-50	Sev. *Aglantha*
6-23-50	*Aglantha*, C
6-30-50	1 *Aglantha*
7-13-50	13 *Aglantha;* 1 ephyra; 1 *Rathkea octopunctata* (with buds)

TABLE 7.—*Gross analysis of plankton, Point Barrow, Alaska, August-September 1948, September 1949-July 1950*—continued

CTENOPHORES

8- 2-48	Yg.; adult *Mertensia*
8- 5-48	Larval forms; various sizes of *Mertensia*
8- 9-48	Egg; cydippid yg. in various sizes
8-12-48	Larval cydippids
8-30-48	" "
9- 4-48	Sm. *Mertensia;* lg. cydippid larvae
9- 9-49	Larvae of cydippids, R
9-10-49	None
9-13-49	"
9-30-49	Cydippid larvae, C; 2 *Beroë*
10-24-49	None
10-31-49	"
11- 1-49	"
11-10-49	Fragments
1-21-50	None
1-25-50	6 sm.; few fragments
1-27-50	None
2-10-50	"
2-25-50	Larvae, R
2-28-50	" "
3- 8-50	5 larvae
3-14-50	6 "
3-23-50	3 eggs; few cydippid larvae
3-29-50	Larval forms, C
4- 8-50	Larvae of *Beroë,* few
4-15-50	1 larva of *Beroë*
4-24-50	1 cydippid larva
5- 2-50	Fragments
5- 9-50	None
5-17-50	4 larval *Beroë,* 2 adults; 2 cydippid larvae
5-23-50	6 " "
5-30-50	14 " "
6-16-50	Yg. *Mertensia,* 5 cm., C

ANNELIDS—POLYCHAETES

8- 2-48	Larval forms; trochophore larvae; larva of *Polydora* (probably *caulleryi*)
8- 9-48	Yg. larval worms, A; trochophore larvae, A
8-30-48	Larval forms
9- 4-48	Larval forms (a few trochophores metamorphosed in finger bowls between 9-4-48 and 9-12-48 so that larval polynoids were recognizable)
9- 9-49	Larval forms, few
9-10-49	Larval forms, C; trochophores, C
9-13-49	Larval forms, C
9-30-49	Larva of spionid (2.5 mm.)
10-24-49	Larval forms, C

TABLE 7.—*Gross analysis of plankton, Point Barrow, Alaska, August-September 1948, September 1949-July 1950*—continued

10-31-49	None
11- 1-49	Larval forms, few
11-10-49	None
1-21-50	1 sm.
1-25-50	1 larva; 1 *Autolytus fallax* with egg sac
1-27-50	4 sm. forms
2-10-50	None
2-25-50	"
2-28-50	2 sm.
3- 8-50	1 sm.
3-14-50	None
3-23-50	"
3-29-50	*Autolytus fallax* with egg sacs, AA; *Syllis fasciata* (with eggs inside), 3; 10 *S. cornuta* with swimming setae
4- 8-50	4 larval forms; 2 trochophores; sev. adult worms, with eggs, going to pieces
4-15-50	10 larval forms; 5 metamorphosing from trochophore stage; *Autolylus fallax* with egg sacs, A; 2 *Syllis cornuta* with swimming setae
5- 2-50	Larval forms, C; trochophores, C
5- 9-50	14 trochophores (sev. kinds); 6 yg. worms
5-17-50	8 larval forms; trochophores, C; 1 ovig. syllid
5-23-50	Larvae, C (with 4 eye spots)
5-30-50	Larvae, A (with 4 eye spots) in various stages
6- 6-50	Larvae, C (feeding on green diatoms)
6- 9-50	Larvae, C
6-16-50	Larvae, C (perhaps spionid)
6-20-50	Larvae, C; 1 polynoid larva
6-23-50	Larvae, C
6-27-50	Larvae, C (at least 2 kinds)
6-30-50	Larvae, few
7-13-50	Larvae, 3 or 4 kinds; sev. kinds of trochophores; 4 larval polynoids

ARTHROPODS—CRUSTACEANS

	COPEPODS	NAUPLII	OTHER
7-24-48	A	C	Many crab larvae
7-25-48	A	C	" " "
8- 2-48	A	A	None
8- 6-48	AA	AA	Crab larvae
8-30-48	A	Few-C	Few other larvae
9- 4-48	A	None	None
9- 9-49	AA	None	Few larvae
9-10-49	AA	"	" "
9-13-49	A	"	" "
9-30-49	AAA	"	Larvae, R
10-29-49	AAA	C	Larvae, C
10-31-49	A	Few	Ostracods, mysids, euphausiids, 2

TABLE 7.—*Gross analysis of plankton, Point Barrow, Alaska, August-September 1948, September 1949-July 1950*—continued

	COPEPODS	NAUPLII	OTHER
11- 1-49	A	R-few	Ostracods, few; 1 yg. isopod
11-10-49	A	C	None
1-21-50	Few-C	7	"
1-25-50	A (1 ovigerous)	4	Ostracods, few
1-27-50	A (1 ovigerous)	None	4 ostracods
2-10-50	C	"	None
2-25-50	A	"	Few larvae
2-28-50	A (5 ovigerous)	"	Larvae, few; 1 sm. amphipod
3- 8-50	A	3 (2 with much oil)	Larvae, few
3-14-50	None	None	Larvae; 2 sm. isopods
3-23-50	A	"	1 sm. isopod *
3-29-50	AA	C	None
4- 8-50	AA**	C	1 sm. isopod *
4-15-50	AAA	None	Larvae
4-24-50	A (some with oil)	C	3 sm. isopods; * 1 yg. cladocere ?
5- 2-50	A (3 ovigerous)	C-A	None
5- 9-50	AA	C	4 sm. isopods; * 2 protozoans
5-17-50	A (2 ovigerous)	AA	None
5-23-50	A (2 ovigerous)	AA	2 zoea
5-30-50	A (ovigerous-C)	AAA (sev. types)	2 protozoea; 10 zoea
6- 6-50	Few	A	None
6- 9-50	C (pair mating)	A	"
6-16-50	A†	A (1 with oil globules ?)	"
6-20-50	A	A	"
6-23-50	A (sev. kinds)	C (sev. sizes)	Few zoea
6-27-50	A (sev. kinds, 1 ovigerous)	AA (3 or 4 sizes) §	1 protozoea (black eyes) Few zoea (huge black eyes)
6-30-50	A (2 kinds, some mating)	C	None
7-13-50	A	AA (all have dark masses in digestive tract)	2 protozoea; 8 zoea; 1 euphausiid; 1 cumacean; 1 shrimp

* Looks like the male of a parasitic form.
** No oil in some, good-sized droplets in others.
† Both juvenile and adult of some species.
§ The majority contained yellow-green food masses, others green food masses.

MOLLUSKS

8- 5-48	1 veliger larva; larval clams
9- 4-48	Tiny snails; trochophores and adults of *Clione*
9- 9-49	Veligers and yg. snails, AA (more than on any other date)
9-10-49	Veligers, R
9-13-49	Veligers very rare; trochophores of *Clione* (now larger)
9-30-49	Trochophores of *Clione* (0.7 mm.)

TABLE 7.—*Gross analysis of plankton, Point Barrow, Alaska, August-September 1948, September 1949-July 1950*—continued

10-29-49	Pteropods, A; veligers, R
10-31-49	Veligers, R
11- 1-49	Veligers, few; 1 yg. clam
11-10-49	None
1-21-50	1 veliger
1-25-50	1 veliger
1-27-50	3 veligers; trochophore of *Clione*
2-10-50	None
2-25-50	Veligers, few; trochophores * of *Clione*
2-28-50	Veligers, C; trochophores of *Clione*
3- 8-50	Veligers, few; trochophores of *Clione;* 1 lg. *Clione*
3-14-50	Veligers, 10; trochophores of *Clione*
3-23-50	Veligers, few; trochophores of *Clione*
3-29-50	Veligers, few; trochophores of *Clione,* C; 2 yg. clams
4- 8-50	Veligers, C; trochophores of *Clione;* (veligers with opercula)
4-15-50	Veligers, C; trochophores of *Clione,* 17; (veligers with opercula)
4-24-50	Veligers, 8; trochophores of *Clione,* C
5- 2-50	Veligers, 5; trochophores of *Clione,* C; 1 yg. *Spiratella*
5- 9-50	Veligers, C; trochophores of *Clione,* C
5-17-50	Veligers, none; trochophores of *Clione,* C; (1 with wings developing)
5-23-50	Veligers, 8; trochophores of *Clione,* C
5-30-50	Veligers, 7; trochophores of *Clione,* C-A
6- 6-50	Veligers, sev. (early stages)
6- 9-50	Trochophores (very early)
6-16-50	1 veliger of *Spiratella*
6-20-50	1 *Clione*
6-23-50	1 *Clione*
6-27-50	Veligers, 2 (2 species); 1 trochophore of *Clione*
6-30-50	1 sm. *Clione,* 1 very sm. *Clione;* trochophores of *Clione;* veligers, few
7-13-50	4 trochophores of *Clione;* 3 veligers of *Spiratella;* other veligers (sev. kinds)

* These trochophores have a large circle of oil droplets around the anterior end.

MISCELLANEOUS

8-30-48	Echiuroid larvae
9- 9-49	Pluteus larva No. 1, few; pluteus larva No. 2, C
9-10-49	Pluteus larvae, few
9-13-49	Pluteus larvae, none
9-30-49	Pluteus larvae, none
10-24-49	Pluteus larvae, rare
10-24-49	Ciliates, AA; appendicularians or tunicate larvae, R
10-31-49	Vorticellids attached to mysid; appendicularians or tunicate larvae, R
10-31-49	Pluteus larva, none
11- 1-49	Pluteus larvae, rare
1-21-50	From 28 hauls made from this date until 7-13-50 no pluteus larvae were observed
1-27-50	1 tintinnid; ciliates, C
3- 8-50	3 appendicularians; few unidentified larvae

TABLE 7.—*Gross analysis of plankton, Point Barrow, Alaska, August-September 1948, September 1949-July 1950*—continued

3-14-50	1 tunicate larva
3-29-50	Foraminifers; few
4- 8-50	Tintinnids, few; nematodes, few; tunicate larva, 1; eggs, unidentified, C
4-15-50	Tintinnids, R; tunicate larvae, 3; fish eggs, few (somites visible)
4-24-50	Tintinnids, few; tunicate larvae, 2
5- 2-50	Tintinnids, few; tunicate larvae, none; dinoflagellates, 3; eggs, C
5- 9-50	2 eggs; tunicate larvae, none
5-17-50	Eggs, few; tunicate larvae, 1
5-23-50	1 yg. Arctic cod (?); tunicate larvae, none
5-30-50	1 nematode (microscopic branching algae have been present for 4 weeks)
6- 6-50	1 huge trochophore (possibly of the echiuroid *Hamingia arctica*)
6- 9-50	1 huge trochophore
6-16-50	2 huge trochophores
6-20-50	1 huge trochophore
6-20-50	Eggs of 2 sizes; fish eggs
6-23-50	Eggs of 2 sizes, C
6-23-50	Few huge trochophores
6-27-50	Few huge trochophores
6-27-50	Eggs, lg., C; eggs, sm., A; eggs, very sm., few
6-30-50	Eggs, lg., few; eggs, sm., A
7-13-50	1 yg. Arctic cod; sm. chaetognaths, C

Examination of the above lists of plankton sampling reveals several items of interest. The spiny types of diatoms were absent from November 1, 1949, to March 23, 1950, but several circular forms were present throughout the winter. The chain type of diatoms became abundant in the spring before the spiny type.

The fact that the winter tows were made vertically and hence covered a very small area as compared with tows made in the usual manner, reduces to little significance the absence of any one form from the plankton for one or two hauls. But the continued absence of a form must have significance even though the hauls were not extensive.

That not a single echinoderm larva appeared in any of the hauls from November 1, 1949, until July 13, 1950, when it was no longer possible to take hauls, is surely an indication that no echinoderms were spawning during the winter.

The trachyline medusa *Aglantha digitale* was present throughout the winter, and the gonads began development on March 29, 1950. Although not shown on the above lists, adults of the jellyfishes *Cyanea* and *Chrysaora* were present throughout the winter (see "Trapping Through the Ice"), and eggs and swimming larvae were observed in *Chrysaora* on November 19, 1949. This fact, plus the presence of an ephyra on July 13, 1950, indicates that much goes on under the ice in winter. The presence of the medusa *Rathkea octopunctata* on July

13, 1950, with well-developed buds is an indication of earlier reproduction of the hydroid.

Larval ctenophores were present up to September 30, 1949, and appeared again on February 25, 1950, and became increasingly abundant from then on. Fragments of ctenophores were found on November 10, 1949, and small ctenophores and fragments on January 25, 1950, showing that these forms were not entirely absent.

The giant trochophores that were present throughout the month of June suggested that they might be those of the echiuroid *Hamingia arctica,* for the latter produces giant eggs (see phylum Echiuroidea, under "Discussion of Animals by Phyla").

Larval polychaetes and small worms were present all during the winter. The main sexual activity and egg-bearing stages of several of the polychaetes occur in winter.

Copepods were present throughout the winter, ranging from common to abundant to exceedingly abundant. Nauplii were much less common during the winter, not becoming abundant until about May 17, 1950. Although never abundant, other crustacean larvae of various kinds were present throughout the winter.

It is an interesting fact that although veliger larvae were never abundant as compared with other forms, they were present throughout the winter. Certain gastropods must lay eggs at various times during the winter or else the larvae spend a long pelagic life. Most of the egg capsules that were dredged or washed ashore during the open season contained young snails at some time, but there were several kinds that contained only eggs and too few were found to determine whether the eggs hatched as swimming larvae or as young snails. It is possible that in some species the eggs hatched as swimming larvae that escaped from the capsules without further development and that these were the veligers found in the winter plankton.

That invertebrate eggs and fish eggs begin to be common to abundant in June is another proof that certain animals either carry on as usual during the winter or produce eggs from oil stored during the open season.

PARASITES AND COMMENSALS

It is unfortunate that more could not be learned of the parasitic and commensal relationships of the animals collected, for these relationships form such an interesting and important part of the knowledge of a fauna. When animals must be obtained by dredging (rather than by digging them from mudflats or sand or by finding them among or under rocks), the determination of commensal relationships is difficult and sometimes impossible.

Among the polychaetes there must be commensal relationships that could not be determined with certainty. For instance, the polynoid worm *Antinoë sarsi* is undoubtedly commensal with the echiuroid worm *Echiurus echiurus alaskanus*. The polynoid *Enipo gracilis* is known to be commensal (Alaska) with the maldanid *Nicomache lumbricalis,* and although both of these worms were collected at Point Barrow they were not found within the same tube. The polynoid *Arcteobia anticostiensis* is also known to be commensal with the terebellid *Pista flexuosa* in Labrador. This polynoid occurs at Point Barrow, and even though *P. flexuosa* was not found there, other suitable terebellid hosts were abundant. One or two of the other polynoids showed characteristics of commensalism, but appearances could not be substantiated by evidence.

The bryozoan *Alcyonidium polyoum* was often found growing on snail shells, and several species of hydroids were found on clam shells and snail shells, especially *Boreotrophon* sp., *Neptunea ventricosa,* and *N.* sp.

The following table summarizes most of the parasitic relationships that were found:

TABLE 8.—*The parasites of Point Barrow, Alaska, and their hosts*

HOST	PARASITE
DECAPOD	RHIZOCEPHALANS
Pagurus trigonocheirus (Stimpson), on abdomen	*Clistosaccus paguri*
	Peltogaster depressus
POLYCHAETES	COPEPODS
Antinoë sarsi	*Herpyllobius arcticus*
Gattyana cirrosa	" "
Harmothoë extenuata	" "
H. imbricata, on head	" "
Terebellides stroemi	*Saccopsis terebellidis*
AMPHIPODS	
Onisimus affinis, in marsupium	Unidentified
Haploops laevis, in marsupium	"
Maera danae, in marsupium	"
DECAPOD	
Eualus gaimardi, under branchiostegite	*Choniostoma mirabile*
TUNICATES	
Boltenia echinata, in branchial basket	*Doropygus* sp.
B. ovifera, in branchial basket	*Schizoproctus inflatus*

TABLE 8.—*The parasites of Point Barrow, Alaska, and their hosts*—continued

HOST	PARASITE
FISH	
Boreogadus saida, on gills	*Hemobaphes cyclopterina*
DECAPODS	LEECH
Sclerocrangon boreas, on exoskeleton	*Crangonobdella murmanica*
	ISOPOD
Eualus gaimardi, on abdomen	*Phryxus abdominalis*

DISCUSSION OF ANIMALS BY PHYLA [3]

Phylum PROTOZOA

Because of the time-consuming techniques involved, no attempt was made to collect protozoans other than the Foraminifera. These are extremely abundant at Point Barrow and are attached to practically everything—hydroids, bryozoans, stones, barnacles, shells, worm tubes, chitons, and tunicates. The furrows in the shells of *Pecten islandicus* are favorite nestling niches, and the tunic of tunicates and the girdle of chitons (*Symmetrogephyrus vestitus*) are places of attachment sufficiently plastic to permit the Foraminifera to form depressions to fit their tests. Other epizoic forms of Protozoa were observed on such animals as crustaceans, mollusks, hydroids, and bryozoans.

Whenever possible, Foraminifera were picked from other animals and preserved and labeled. Sediments washed from the collections were also saved and labeled. All this material was turned over to Dr. Alfred R. Loeblich, Jr., and from it he identified 66 species, including 4 new genera and 11 new species. In the summer of 1950, when Dr. Loeblich spent a few weeks at Point Barrow, he accompanied the writer on dredging trips and during this time he added 9 more species, including 2 new ones, to the collection, making a total of 75 species. The results of the study of these Foraminifera have already been published (Loeblich and Tappan, 1953).

Phylum PORIFERA

Sponges often formed a conspicuous part of the fauna of the dredge hauls. Except in the waters from Eluitkak Pass to Elson Lagoon (depth 40 feet, bottom of stones, gravel, and mud), almost no sponges

[3] Detailed information concerning individual species could not be included in this discussion. Any reader interested in more specific data on any animal or group of animals should contact the writer.

were taken at depths of less than 110 feet. The stalked, flared-goblet-shaped *Echinoclathria beringensis* (Hentschel) was common at Eluitkak Pass, as was also *Halichondria lambei* Brønsted. Specimens of the former species from Eluitkak Pass were larger (up to 9 inches across) than from any other station, although this species occurred in practically every haul from depths greater than 110 feet, up to 741 feet. Since there is a strong current at Eluitkak Pass and the water is often very muddy and sometimes somewhat diluted, the ability of this sponge to thrive is remarkable. Often quantities of mud could be squeezed from a specimen. It is muddy white or grayish in color and has a disagreeable odor. A copepod, probably of a new species, is often found in large numbers on the inner face of the "goblet."

From a depth of 522 feet a portion of a *Polymastia andrica* de Laubenfels was dredged. This sponge, which was in the form of a small-bore cylinder, was a beautiful rose red in color.

From a depth of 741 feet two specimens of a new sponge, *Craniella craniana* de Laubenfels, were dredged, and a third at 438 feet. The first two specimens were from a worm-tube and mud bottom, the other from a stony bottom. All were greenish gray in life. The largest specimen was approximately 2 inches in diameter and 4 inches high. The long spicules of this sponge are massed in cone-shaped projections arranged in a manner that caused the staff to refer to the animal as the "pineapple sponge." At least two species of somewhat amorphous sponges, identified as *Myxilla incrustans* (Johnston) Lundbeck and *Topsentia disparilis* (Lambe) Burton, were often found completely surrounding a group of barnacles (*Balanus rostratus apertus* Pilsbry) except for the apertures of the barnacles.

The color of sponges does not last many months in preservative. Some of the yellow sponges at Point Barrow even faded in the laboratory before they were placed in preservative. One unusually bright one faded to a pale yellow while preparations were being made to photograph it. Other sponges that were referred to as a "dirty yellow" faded to a dirty white before they could be preserved.

The collection of sponges was turned over to Dr. M. W. de Laubenfels who identified (de Laubenfels, 1953) and described 10 species, 3 of which were new and included 1 new genus. Unfortunately, not all the material was identified.

Phylum COELENTERATA

At least in number of individuals, if not in number of species, the coelenterates at Point Barrow are extremely abundant. Six or seven

species of gymnoblasts and about 15 species of calyptoblasts were collected. There are about six species of anthomedusae, perhaps two of leptomedusae, about three of trachymedusae, and three or four of jellyfishes. Since no special effort was made to collect jellyfishes and other medusae, the number of species of coelenterates may be much higher than here indicated.

As yet no one has been found to identify the jellyfishes and medusae. Dr. Cadet Hand is working on the sea anemones, and after completing this work he expects to identify the hydroids. Dr. Frederick M. Bayer identified the one octocoral found.

Order HYDROIDA

Suborder GYMNOBLASTEA

Colonies of *Hydractinia,* which partially or completely covered snail shells of the genera *Polinices, Neptunea,* and *Buccinum,* occupied either by hermit crabs or by the original owners, were taken at Eluitkak Pass (gonophores present on August 10, 1948) by hand dredging from 50 feet on July 26, 1948, and by dredging from depths of 110 to 453 feet from August until the middle of October.

The most striking hydroid was a deep flesh-colored species of *Corymorpha* dredged from a sandy-muddy bottom at a depth of 10 feet on July 21, 1948 (gonophores present). Other specimens were washed ashore, the largest measuring 100 mm. in length. A specimen 55 mm. long collected on October 16, 1949, was double-headed: at about two-thirds the height of the stem it branched and gave rise to another polyp about one-half the size of the main polyp.

A species of *Garveia* was dredged occasionally (large flesh-colored gonophores present on October 6, 1949). A species of *Tubularia* with long straw-colored or tan unbranched stems up to 150 mm. in length and with polyps at least 20 mm. across was taken frequently but sparingly from depths of 80 to 477 feet. (See *Tubularia* under "Abundance of Animals.")

Suborder ANTHOMEDUSAE

Sarsia flammea Hartlaub was undoubtedly the most abundant hydromedusa at Point Barrow. Although common at various times, during July 1949, and especially between July 20 and July 27, there were countless numbers in the water along the shore, and many were carried ashore into pools in the gravel. On July 11, 1950, two specimens were taken through the ice in a screen trap at a depth of 37 feet.

Less abundant than the above species, *S. princeps* (Haeckel) was nevertheless common during the week of July 20 to July 27, 1949, and was present at other times. One specimen taken on July 26, 1949, had five radial canals and five tentacles.

A single specimen of *S. tubulosa* (M. Sars) taken in a plankton tow on July 16, 1948, forms the first record of this species from the western Arctic.

About six specimens of what is undoubtedly the medusa of *Bougainvillea superciliaris* L. Agassiz were taken near shore in August 1948 and July 1949. One taken on July 23, 1950, appeared to be sexually mature.

Six specimens of *Rathkea octopunctata* (M. Sars) were taken near shore in August 1948, and another one in a vertical plankton haul through the ice at the 80-foot hole 1.6 miles from shore on July 13, 1950. This transparent medusa is about 3 mm. high and 2 mm. in diameter, with brown manubrium, dark-brown lithocysts, and brown medusa buds. All the medusae were bearing budding medusae, and some of the buds were in turn producing buds before becoming dedetached from the parent. Young buds are transparent, appearing somewhat like blisters, but become tan and then brown as they grow older.

The circumpolar *Halitholus cirratus* Hartlaub was a seasonal visitor at Point Barrow. Occurring less frequently than *Halistaura,* for instance, it nevertheless was common on August 3, 1948, September 3, 1949, and July 20, 1950.

Suborder Calyptoblastea

Hydroids of this group were often growing on other hydroids or other animals: *Campanularia* on *Obelia, Sertularia,* and *Thuiaria; Clytia* (?) on the clams *Nuculana* sp. and *Macoma calcarea,* and on the legs of a pycnogonid; *Obelia* on the legs of the king crab *Paralithodes camtschatica;* and *Ophiodissa* (?) on the stem of *Tubularia.*

The most abundant hydroid, which the writer tentatively refers to as *Lafoeina maxima* Levinsen, was taken in large masses at Eluitkak Pass and from a few to numerous colonies were taken in every dredge haul from 110 to 477 feet, being particularly abundant at 453 and 477 feet. This hydroid, which resembles strands of chenille as much as it does a hydroid, was usually attached to rocks but was also found on barnacles, old shells, and even bryozoans. Two different species may be represented, for both branched and unbranched forms were common. Colonies up to 130 mm. in height were not uncommon.

New colonies were taken through the ice on February 14, 1949, at a depth of 149 feet. This is a truly Arctic species that has been known from eastern Canada, Greenland, Iceland, and the European, Russian, and Siberian Arctic, but has not been reported previously from Point Barrow.

Another common species, probably *Sertularia* sp., was taken in every haul from 110 to 477 feet, and large colonies were taken through the ice on February 18, 1950, at 162 feet. The simple ascidian *Molgula griffithsi* often grew on its stems and Foraminifera were frequently found on it. (See "Reproduction Phenomena.") Colonies of the treelike *Thuiaria elegans* Kirchenpauer, up to 200 mm. in height, were dredged at Eluitkak Pass and at depths of 120 to 741 feet. Since this species has been known only from Flower Bay in Bering Sea, the Point Barrow specimens represent a northward extension of range into the Arctic. Another species of *Thuiaria,* possibly *T. lonchitis* (Ellis and Solander), was common at depths of 80 to 477 feet.

Suborder Leptomedusae

Medusae of a species of *Obelia* were taken in plankton tows in August of 1948 and 1949. They were transparent, with brown gonads and a pale, translucent, tan manubrium. In most specimens there appeared to be a progression of development in the gonads in that one gonad was small, another a little larger, the third fairly well developed, and the fourth still more mature. One medusa had eaten a green ciliated larva too large to be engulfed at one time and part of it was projecting from the mouth while the cilia of the larva continued beating.

Other Leptomedusae were collected from shore by means of a net.

Order TRACHYLINA

Suborder Trachymedusae

The transparent *Halistaura cellularia* (A. Agassiz), with peach-colored canals, was common about the middle of August and was seen occasionally at other times.

The most consistently abundant hydromedusa was *Aglantha digitalis* (O. F. Müller), which was plentiful to extremely abundant at times. Specimens were observed from the latter part of June, when they were taken through holes in the ice, to the first week in September. On August 6, 1948, all sizes were present, ranging from young specimens with gonads that were mere specks to full-grown ones with

long mature gonads. The four oral lobes, that perform startlingly like fingers in grasping food, act with amazing rapidity and efficiency.

An unidentified trachymedusan 24 mm. high and 47 mm. in diameter was taken on July 24, 1949. The manubrium, radial canals, and tentacles were translucent white, and the large, lobate gonads were cream-colored. Red-eyed phronimids with red-and-white bodies nestled into the subumbrellar surface of the medusa with their backs to the subumbrella. They had pulled the tissue of the latter around their backs and held it with their feet. These phronimids may be the young of *Hyperoche medusarum.*

Class SCYPHOZOA

Order SEMAEOSTOMEAE

Since no special attempt was made to obtain jellyfishes, it is probable that more species occur at Point Barrow than are included in the present collection. At times the water alongshore in the vicinity of Point Barrow literally teemed with them, especially during the summer of 1948 when ice floes were always present. They may have been just as numerous in 1949 and 1950, but if so they were farther from shore and less obvious.

There has been much discussion about the species or varieties of *Aurelia.* Some authors consider the several forms as mere varieties of *A. aurita* (Linnaeus), while others give them specific rank. Point Barrow should be a good place to study *Aurelia* and *Cyanea,* for both of these jellyfishes occurred in a variety of color forms.

Countless thousands of a uniformly translucent, pale olive-tan *Aurelia* ranging up to 2 inches in diameter were at the edge of the water on August 12, 1948. One specimen about 5 inches in diameter with brown tentacles and gonads was also observed. Again on August 16, 1948, the small, pale olive-tan specimens were exceedingly numerous, and a few white specimens about 4 or 5 inches in diameter with brown tentacles and gonads were seen. One specimen was white with white tentacles and brown gonads.

Young specimens of *Aurelia* (and also of *Cyanea*) up to 2.5 inches in diameter withstand a wide range of temperature. Taken into the laboratory from water barely above freezing, they will live for days in pans of water that soon reaches room temperature.

Cyanea capillata (Linnaeus) was also exceedingly abundant, but it occurred more consistently throughout the summers from 1948 to 1950 than did *Aurelia.* Specimens usually ranged in color from pale tan to yellowish brown with dark-brown canals and tan to brown

tentacles, but on August 17, 1949, a large orange-brown specimen was seen. Frequently a form with a whitish bell and delicate flesh-colored tentacles was seen. This form, 4 to 12 inches in diameter, was abundant on September 8, 1948, and common on September 15, 1949. Specimens of *Cyanea* species up to 20 inches in diameter were taken through holes in the ice throughout the winter of 1949. Ephyra and postephyra stages less than half an inch in diameter, with transparent bell and lobes and very pale flesh-colored central parts, were taken in August 1948 and from September to November 1949.

A species of *Chrysaora* was seen frequently but never in such abundance as the above two species. On November 19, 1949, several specimens contained yellowish-brown eggs, some of which were rotating and developing into active planulae.

Two species of commensal phronimids, *Hyperia medusarum* and *Hyperoche medusarum,* were found with *Cyanea* and *Chrysaora.* (See "Amphipoda.")

Class ANTHOZOA

Subclass Alcyonaria

One species of the octocoral *Eunephthya rubiformis* (Pallas) was found. It was exceptionally abundant at Eluitkak Pass and was dredged from 125 to 522 feet. Colonies up to 6 inches high were not uncommon. Occasionally instead of colonies of the usual reddish color, a pale-orange or a beautiful apricot-colored colony was taken.

Subclass Zoantharia

Order ACTINIARIA

Sea anemones were exceedingly abundant in some hauls, rare or absent in others. The most plentiful species, *Stomphia coccinea* (O. F. Müller) was characterized by brick-red markings on a cream background, with tentacles about the color of the markings. Small specimens do not show these markings so vividly. Adult specimens that were a delicate peach color throughout were frequently taken, but they may belong to another species. Specimens 65 mm. high and with a basal diameter of 70 mm. were dredged. This species was taken at Eluitkak Pass and at most of the rubble-bottom stations. In one dredge haul from 130 feet (on September 15, 1948) there were 123 specimens, and hauls from several other stations brought up 50 or more.

One specimen of this species taken on October 14, 1949, at 175 feet

was filled with eggs measuring 697 microns in diameter that were clearly visible through the body wall.

An amazing phenomenon was observed in this anemone. When it was subjected to unfavorable conditions, such as overcrowding in a pan or jar of sea water, it cast out through the mouth a re-formed translucent white inner lining with translucent stubby tentacles, the latter so short that they were mere tubercles. This offspring was somewhat suggestive of a pickled onion, for the lines of the septa were clearly visible through the body wall. If conditions remained adverse, more offspring were cast off, each one becoming smaller than its predecessor.

That this phenomenon is not limited to laboratory conditions was evidenced by the fact that on August 21, 1948, at a depth of 140 feet, one of these translucent anemones 16 mm. high and 11 mm. in diameter was dredged. At the time this was believed to be a new species of an unusual nature, and it was not until the end of the dredging season in 1949 that its true identity became known, but it was then too late for experimental investigation since no more specimens could be dredged. Specimens left overnight in jars with too little water yielded as many as six offspring each, the smallest one being no larger than a pea. On September 2, 1949, there was washed ashore a translucent anemone 21 mm. in diameter in which the basal disk, the mouth, and the tentacles were colored like those of the adults mentioned above although in a somewhat paler version. The tentacles were short and stubby but longer than those of a newly cast offspring. This individual was obviously a cast offspring that had undergone subsequent development.

Other anemones were common—a purplish-red, an oyster-white, a lavender form, and some with white base, peach-colored column, and translucent peach tentacles with whitish tips. Two broad, uniformly lemon-yellow specimens were dredged on August 17, 1949, at 438 feet. Two specimens of *Halcampa duodecimcirrata* (Sars) with a muddy white column, white peristomium, and olive-gray tentacles were taken, one at 70 feet, the other at Eluitkak Pass. Two other species of burrowing anemones were found.

Order CERIANTHARIA

From 1 to 30 specimens of *Cerianthus,* possibly *borealis* Verrill, were taken in hauls from 22 to 132 feet. Since there was considerable variation in the proportion of the diameter to the length, it is possible that two species are represented.

Phylum CTENOPHORA

Like the jellyfishes, the comb jellies were much more abundant alongshore during the drift-ice summer of 1948 than during the open-water summers of 1949 and 1950. Three species, each belonging to a different order, were identified. At times all three would be abundant at the edge of the water and again only one or two species would be in evidence from the shore; at other times none were seen. Sometimes they would be washed ashore in great numbers.

Mertensia ovum (Fabricius) was especially abundant on July 26, 1948, and again on September 30, 1949. On both of these dates the majority of the specimens were about 10 mm. long, but individuals up to 60 mm. in length were observed at various times. Some individuals taken on the morning of August 5, 1948, were gorged with plankton; one 9 mm. long and 7 mm. in diameter had ingested one appendicularian, several copepods and ostracods, strings of diatoms, protozoans, arrow worms, nauplii, and a piece of red tentacle.

In the summer of 1948 *Bolinopsis infundibulum* (O. F. Müller) was first observed on August 2, when a specimen only 55 mm. long and 35 mm. wide was taken alongshore. Later, individuals exceeding 200 mm. in length were common.

Although it never occurred in such enormous numbers as either *Mertensia* or *Bolinopsis,* the rose-colored *Beroë cucumis* Fabricius was more frequently present along the shore than were the other two species. In 1948 it was first observed on July 20, in 1949 on July 22, and in 1950 on July 20. In 1949 it was observed alongshore until September 30, and throughout the winter fragments were seen in leads or were taken through holes in the ice.

Beroë cucumis could be preserved satisfactorily, but despite time and effort spent on the other two species, no success was achieved. Solutions that preserved the animals also contracted them to such an extent that they could not be worked on, and those that left the animals in a relaxed, transparent state completely dissolved them within a period of six months.

Point Barrow would be an excellent place for life-history studies of the ctenophores, for often all stages of development from larvae to adults are present at one time.

Phylum PLATYHELMINTHES

Class TURBELLARIA

Only two species of polyclad flatworms were taken, but one of these, *Notoplana atomata* (Müller), was present in every dredge haul from a bottom that afforded niches and hiding places, namely, Eluitkak

Pass and at depths of about 125 to 741 feet. One dredge haul from Eluitkak Pass yielded 20 specimens of this worm, which nestled between the abundant growths of barnacles and no doubt fed on them. Thick growths of bryozoans and of the octocoral *Eunephthya rubiformis* also provided refuge for it. In life *Notoplana atomata* is light beneath and rosy tan above, the latter color produced by minute tan spots. Internal opaque white spots show through the dorsal surface. Although this is the commonest polyclad of northern shores of the North Atlantic, both in Europe and America, it has not previously been reported from western Arctic shores.

A new species of polyclad, *Acerotisa arctica* Hyman, was found only rarely: 2 specimens on October 6, 1949, at 295 feet, 1 on September 1, 1949, at 328 feet, and 1 on October 11, 1949, at 453 feet—all on stony bottom. It is pale red, with a deeper red longitudinal band through the middle.

Both of these species, with a description of the new one, are included in a recent publication by Hyman (1953).

Class CESTODA

Since parasitology is a study in itself, no search was made for tapeworms, but any that were found were preserved. Specimens up to 600 mm. in length and from 3 to 4 mm. in width were taken from the intestine of a bearded seal, *Erignathus barbatus* (Fabricius). Another much smaller species was found by the hundreds at the edge of the water and on the bottom of a fresh-water pond near the Point. They had obviously come from bird droppings, and since dozens of loons were on the water and flying around, no doubt this bird is the secondary host of the tapeworm.

Phylum NEMATODA

Free-living nematode worms were abundant and many of them were unusually large. They could be found among bryozoans and hydroids, in the interstices between individuals in a colony of barnacles, in the mud and debris in holes in rocks, in the growth on rocks, and in more specialized habitats. Specimens of the jell-like cylindrical bryozoan *Alcyonidium enteromorpha* Soule were somewhat wrinkled longitudinally and within these wrinkles several nematodes were ensconced. Others were found at the bases of the simple tunicates *Chelyosoma macleaynum* and *Molgula griffithsi*. Still others were found between colonies of the compound ascidian *Didemnum albidum* and the worm tubes (*Pista maculata*) on which they were growing.

Two striking nematodes, 290 mm. and 325 mm. in length, were washed ashore on August 18, 1948. These were white, with the head end tipped with black, and a gray, or hyaline, longitudinal stripe along the ventral side.

The nematodes were sent to Dr. B. G. Chitwood for identification. He expects to describe a new species of *Thoracostoma* that was found in a rock from a depth of 130 feet on September 15, 1948.

No attempt was made to find parasitic nematodes, but specimens up to 180 mm. in length and 1 mm. in diameter were abundant in the intestine of the bearded seal. Masses of another species so filled the deeper nasal passages of this seal that one wondered how the animal could breathe.

Phylum NEMERTEA

Nemerteans were more abundant off Point Barrow than in any other place within the collecting experience of the writer. They occurred in practically every haul from 30 to 741 feet. The collection was turned over to Dr. Wesley R. Coe for identification, and the results of his study were published in 1952. From the 300 specimens sent him (many duplicate specimens of certain species were not preserved), Dr. Coe identified 24 species, only 3 of which had been taken previously in the Point Barrow area of the Arctic (Cape Smythe, Wainwright, etc.). At least 10 of the species had not been recorded previously from Arctic seas: *Tubulanus capistratus* (Coe), *T. albocinctus* (Coe), *T. frenatus* (Coe), *Micrura alaskensis* Coe, *Paranemertes peregrina* Coe, *Nemertopsis gracilis* Coe, *Amphiporus imparispinosus* Griffin, *A. pacificus* Coe, *Tetrastemma aberrans* Coe, and *T. bicolor* Coe. Four of the species found at Point Barrow are also known from the Southern Hemisphere: *Tubulanus annulatus* (Montagu), *Lineus ruber* (O. F. Müller), and *Cerebratulus fuscus* (McIntosh) from the coast of South Africa, and *Emplectonema gracile* (Johnston) from the coast of Chile. *Tubulanus frenatus* had been recorded previously only from southern California.

The most abundant genus was *Amphiporus* with seven species, and the most abundant species were *A. angulatus* and *A. lactifloreus*. *A. angulatus* was collected by Stimpson in Bering Strait in 1857. In view of its abundance at Point Barrow and its size and conspicuous coloration, it seems remarkable that it had not been taken previously in this area.

Two living specimens of *Micrura impressa* that washed ashore on September 26, 1949, had taken measures of self-preservation. They had literally tied themselves in knots, curled up into balls, and then

secreted mucous bags about themselves. This species has been known only from the type specimen from Bering Strait and later from Japan.

These Point Barrow nemerteans have added to the knowledge of circumpolar distribution. Coe (1952) states: "Even at the present time no nemerteans are known from the Polar seas between the Point Barrow area and northwest Greenland on the east and Novaya Zemlya and Franz Josef Land on the west."

Phylum SIPUNCULOIDEA

Two or three species of sipunculids were collected, the most abundant being *Golfingia margaritacea* (Sars), which occurred at Eluitkak Pass and at nearly every station from 120 feet to 741 feet. From 1 to 11 specimens were taken in each haul. They were found among masses of barnacles, in the interstices among pebbles and gravel that covered the tunicate *Molgula,* and among debris gathered around old holdfasts of tunicates and hydroids. The Point Barrow specimens extend the range of this species from the 54th parallel of latitude into the western Arctic to the 71st parallel.

A single individual of a species of *Phascolion* was dredged from 741 feet, and although it may well be new it was too small and contracted for anatomical study.

The sipunculids were identified by the late Dr. W. K. Fisher.

Phylum PRIAPULOIDEA

Two species of this phylum were found; the better known of the two was taken less frequently than the rare one. One specimen of *Priapulus caudatus* Lamarck was dredged from 741 feet and another was taken through the ice on February 18, 1950, from 162 feet. Four other individuals, ranging in length from 70 to 110 mm. were washed ashore. These specimens extended the range of this species into the western Arctic.

A single small specimen of *Halicryptus spinulosus* von Siebold was dredged at Eluitkak Pass on August 1, 1950, and 17 specimens, ranging in length from 70 to 170 mm., that washed ashore were collected. Only small examples of this species had been taken previously, the largest, recorded by Théel from Spitsbergen, being 27 mm. in length. This species has been recorded from West Greenland on the east and from the Kara Sea on the west but had never before been taken from the North American Continent.

The writer is indebted to the late Dr. W. K. Fisher for identifying these species and for furnishing other data.

Phylum ECHIUROIDEA

Two species of echiuroid worms were collected. One of the most abundant of the mud-dwelling animals at Point Barrow is *Echiurus echiurus alaskanus* Fisher, but it lives so far beneath the surface in such stiff mud that only small specimens were brought up by the dredge, and then only rarely. However, during the summers of 1949 and 1950 hundreds of these worms were washed out of their burrows and thrown ashore during storms. About half of these storm-tossed creatures were minus the proboscis. Specimens with short proboscides in the process of regeneration were common. A scale worm, *Antinoë sarsi* Kinberg, undoubtedly commensal with *Echiurus,* was also washed ashore in numbers.

Spawning time was not determined for this animal. Males collected on October 16, 1949, had sperm in the storage sacs and females had eggs within the body cavity. These eggs, which were white, granular, and spherical, were 175 microns in diameter.

Whether prompted by hunger or by the urge to add variety to their diet, or perhaps by both, the Eskimos seldom overlook an opportunity to obtain food. Chester Lampe, one of the Eskimo employes at the Arctic Research Laboratory, told the writer that the older Eskimos used to eat any *Echiurus* that washed ashore. He said they would "cut off the head" and eat the remainder of the animal. What they actually did was to cut off the anal end, which is encircled by a double row of setae; they mistook the proboscis for a tail.

Hamingia arctica Koren and Danielssen, a bright deep-green echiuroid with a bifurcated proboscis, was found only on the beach following storms and less than 10 specimens were collected. One specimen with a body 75 mm. long had a proboscis 44 mm. long; the largest, with a body 96 mm. long and 12.2 mm. in diameter, had lost its proboscis.

The body wall of a female collected on August 10, 1950, had been torn so that an egg sac, also torn, was extruded and the eggs were visible. These eggs, which were bright coral, were 900 microns in diameter—enormous for an echiuroid. They appeared to be fertilized, perhaps by some other specimens that were in the pan.

Although this species appears to have a wide distribution it has been taken only sparingly and there were no specimens of it in the U. S. National Museum. It has been collected in East Greenland, Spitsbergen, the Murman Sea, and east to the Barents Sea, Iceland, and the west coast of Norway. It was taken in the Antarctic by the *Discovery* Expedition and in the South Shetlands at a depth of 404.5

fathoms. The Point Barrow specimens extend the range of this species to the western Arctic.

Phylum CHAETOGNATHA

Three species of arrow worms were taken, the most abundant being *Sagitta elegans* Verrill. Since only surface plankton tows were taken, there is a probability that the other two species are more abundant than the haul would indicate. The writer is indebted to Dr. E. Lowe Pierce for identifying this group.

Sagitta elegans Verrill (probably var. *arctica* Aurivillius, the form commonly found in Arctic waters) is exceedingly abundant at times at Point Barrow. During the middle of July 1948 plankton tows near shore brought in thousands of individuals 13 to 27 mm. in length. These had immature gonads. Some 28-mm. specimens taken on September 27, 1948, had long, slender ovaries and visible testes; others had very small ovaries. Dunbar (1941b) discusses the breeding cycle of this species.

In July, when the ice was melting rapidly, *Sagitta* survived when the salinity of the surface water was only 18.12 to 15.22 parts per thousand, but on July 16, 1948, when the salinity dropped from 15.22 to 5.81 between 9 a.m. and 4:30 p.m., untold millions were killed.

Living *Sagitta* are caught and eaten by ctenophores, jellyfishes, and hydromedusae. Those that fall to the bottom are soon devoured by amphipods.

Collection records for this species were made from September 9, 1949, to July 13, 1950, collections from January through June being made by vertical plankton tows through holes in the ice. During February and until late in March (for 6 tows), no *Sagitta* were brought in, but they were taken throughout the remainder of the winter season and became abundant in June. A few specimens taken on June 20, 1950, were 11 mm. long and others were between 22 and 25 mm. long, indicating two age groups.

On September 27, 1948, two specimens of *Sagitta maxima* ? (Conant) 50 mm. in length were taken with a dip net from an ice cake grounded near shore. A strong offshore wind was blowing the surface water seaward and the deeper water was upwelling.

Also on that same date, eight specimens of *Eukrohnia hamata* (Mobius) were taken in the same manner as the above species. These were about 40 mm. long, with well-developed testes and long ovaries containing well-developed eggs. Two of the specimens were carrying young in a marsupium formed by folding the posterior lateral fins

together—a phenomenon hitherto unknown in arrow worms. In the laboratory some of the young, which were nearly 3 mm. long, began escaping from the marsupium.

This is said to be a bipolar, cosmopolitan species, restricted in warmer seas to deeper water. In colder waters it may be found close to the surface, but even in the Arctic it occurs mainly in deep water (Kramp, 1938b; Dunbar, 1942b).

Had it not been for the upwelling of deeper water, this species and *Sagitta maxima* probably would not have been taken at Point Barrow, for even the cosmopolitan *S. maxima* usually occurs only in the deeper parts of the ocean, never less than 200 meters below the surface in tropical and temperate regions (Kramp, 1938a).

Phylum BRACHIOPODA

Only two species of brachiopods were found. Dr. G. Arthur Cooper, who identified these, will report on some noteworthy characteristics of the smaller species in a future publication.

Shells of *Hemithyrus psittacea* (Gmelin) were common, and living specimens were occasionally brought up from depths of 120 to 741 feet. The hauls from 328, 295, and 453 feet yielded the greatest numbers, 11, 6, and 12, respectively. Specimens from 20 to 22 mm. in length appeared to be about 5 years old, and large ones were more abundant than small ones. Specimens between 3.6 mm. and 7.6 mm. long were taken in September and October at depths of 328, 217, 477, and 453 feet. Although this is a circumpolar, Arctic-Boreal species, this is apparently the first record from Point Barrow.

The smaller *Diestothyris spitzbergensis* Davidson was taken at depths of 110 to 741 feet, usually alive. In life the shell is tan. The largest shells of this species were slightly over 15 mm. long, 12.9 mm. wide, and 5.2 mm. in depth, and were from 3 to 5 years old. The hauls from 150, 741, and 152 feet yielded 6, 5, and 7, respectively. The greatest number, 13, was taken through the ice on February 18, 1950, at a depth of 162 feet. Nine of these contained eggs, one contained sperm, and in three the sex could not be determined without making sections of the gonads. Nine of the eggs measured from 195 to 227 microns in diameter, with an average of 211 microns. Two small specimens 3.6 mm. and 4.1 mm. long were taken from 477 and 741 feet, respectively.

Phylum BRYOZOA

The bryozoans, or moss animals, comprise an extremely important part of the bottom fauna at Point Barrow and were found in large

numbers. There is scarcely a stone without at least one colony of encrusting bryozoans; many bore several colonies, and often the dredge brought up stones with the entire surface covered. Bryozoans are also found on pecten shells, snail shells, tunicates, crabs, large isopods, barnacles, and other bryozoans, and on holdfasts of tunicates, hydroids, and other bryozoans. The upright forms are exceedingly abundant. Attached to stones, they provide refuge and places of attachment for innumerable other animals.

The collection of bryozoans was turned over to Dr. Raymond C. Osburn, who identified 99 species, among them 12 new species and 1 new variety. All these species are mentioned and the new species described by Osburn in his monograph, "Bryozoa of the Pacific Coast of America" (in three parts, 1950, 1952, 1953) and by Soule (1951). The majority of the Arctic forms treated by Osburn were from the MacGinitie Point Barrow collection.

Order GYMNOLAEMATA

Suborder Cheilostomata-Anasca

By far the most abundant of the upright forms was *Eucratea loricata* (Linnaeus), which forms large bushy colonies up to 6 or 7 inches in height. It was taken in all hauls from bottoms affording places of attachment (Eluitkak Pass, and from 110 to 741 feet), and even from the carapaces and legs of crabs. Small colonies were also found in 7 feet of water in Elson Lagoon where the water was brackish. Colonies taken at Eluitkak Pass on August 6, 1948, had coral-colored eggs. This species was common in the dredge hauls made through the ice during the winter.

Carbasea carbasea (Solander), a foliaceous, upright form, was also common in hauls from Eluitkak Pass and from most depths of 110 to 741 feet, and in winter dredge hauls. Brown bodies were noted in February as well as in August. Colonies taken at Eluitkak Pass on August 30, 1948, had two sets of barnacles, one with individuals about 4 mm. across the base, the other 0.75 mm. to 2.0 mm. Colonies taken at the same locality on September 2, 1948, had barnacles up to 6 mm. in diameter. The bases of the minute barnacles fitted into the bases of the bryozoan cells.

A few colonies of *Terminoflustra membranaceo-truncata* (Smitt) were taken at 140, 477, and 741 feet. The large colony from the latter depth had the following bryozoans growing on its dorsal surface: *Tricellaria erecta* (Robertson), *Rhamphostomella bilaminata* (Hincks), and *Cauloramphus cymbaeformis* (Hinks).

Bidenkapia spitzbergensis (Bidenkap) was common and conspicuous in dredge hauls for it often forms large colonies of laminate frills. Several colonies taken on October 14, 1949, at 175 feet bore ovicells, and one large colony practically surrounded a large mass of sponge. A new variety, *alaskensis* Osburn, was collected at 140 feet.

The new species *Tegella magnipora* Osburn also forms large, laminate, orange-colored colonies. It was taken at depths ranging from 150 to 420 feet.

Next to *Eucratea loricata* in abundance among the erect, branching forms of bryozoans was *Tricellaria erecta* (Robertson), which forms cream-colored colonies several inches in height and width. It was taken at depths ranging from 110 to 741 feet, attached to stones, tunicate holdfasts, hydroids, other bryozoans, and the carapaces and legs of crabs. It was especially abundant at 175 feet. It is new to the Arctic.

In the matter of abundance, *Dendrobeania murrayana* (Johnston), in its typical form and several varieties, including *fruticosa,* vies among the bushy forms with *Eucratea loricata* and *Tricellaria erecta.* A muddy tan in color, it forms colonies up to several inches in height that were common to abundant in most hauls and were present in all hauls from 125 to 522 feet attached to stones, holdfasts of tunicates, crabs, and other animals.

Suborder Cheilostomata-Ascophora

Three species of *Hippothoa,* forming a delicate tracery over stones, shells, and other objects, were common. *H. hyalina* (Linnaeus), is new to Point Barrow, *H. divaricata* Lamouroux is new to the Arctic as well as Alaska, and *H. expansa* Dawson is new to the western Arctic and to Alaska.

Ranging in color with age from pale rose to dark purple, *Stomachetosella sinuosa* (Busk), which forms round encrusting colonies on shells, is common at Point Barrow. Two bright-red colonies, 15 mm. and 18 mm. in diameter, were taken on October 6, 1949, at 295 feet. It is new to the western Arctic.

The related *S. cruenta* (Norman) forms white or yellowish encrusting colonies that may be deep red when old. The new species *S. distincta* Osburn forms shining, encrusting colonies on shells and stones. The type was taken from 217 feet on September 6, 1949.

Ragionula rosacea (Busk) forms beautiful, lobed, pale-peach colonies attached by a "stem" and spreading base to stones. The colonies at Point Barrow are exceptionally large—one colony with 10 lobes

measured 22 mm. wide and 18 mm. high. This is the first record from the Pacific side of the Arctic.

Without doubt *Pachyegis princeps* (Norman) is the most abundant and conspicuous encrusting species at Point Barrow. It forms coarse, reddish-brown colonies on stones and shells, sometimes completely enveloping a stone. There was scarcely a stone taken from 175 and 453 feet without at least one colony of this species. It occurred from 110 to 741 feet. The yellowish-brown *P. brunnea* (Hincks) is also common. Both species are new to the western Arctic.

Although not abundant, *Porella compressa* (Sowerby) is a common and conspicuous species that forms large foliate colonies up to 100 mm. high and wide. It was taken from 110 to 522 feet. One large colony from 522 feet had three species of bryozoans, young barnacles, an annelid (*Spirorbis*), many Foraminifera, and a compound tunicate *Didemnum albidum* growing on it. It is new to the Pacific side of the Arctic.

Seven species of *Rhamphostomella* were taken, including the new *R. gigantea* Osburn, which forms large colonies of erect, foliate expansions and frills that rise to a height of 80 mm. and vary in color from greenish yellow to bright yellowish orange to deep orange. Colonies were taken from 80 to 420 feet.

Costazia nordenskjoldi (Kluge) occurs abundantly, forming white, almost globular masses about 5 to 8 mm. in diameter that surround stems of hydroids, bryozoans, holdfasts of tunicates, etc. It is new to the Pacific area of the Arctic.

The branching forms *Costazia surcularis* (Packard) and *C. ventricosa* (Lorenz) were in hauls from 110 to 741 feet. The latter species bore ovicells on October 11, 1949, and eggs were present on August 17, 1949. Both species are new to the western Arctic.

The beautiful branching *Myriozoum subgracile* d'Orbigny forms large white colonies sometimes 8 inches high. A very large colony matted with sponge and with hydroids growing from the sponge was taken at 125 feet. It is new to the Arctic.

Suborder Ctenostomata

The soft encrusting *Alcyonidium polyoum* (Hassell) was usually found on shells (*Buccinum* and *Neptunea*), on barnacles, and holdfasts of tunicates. Colonies taken from 453 and 149 feet were bearing ovicells. Colonies from 152 feet contained eggs that averaged 112 microns in diameter. It is new to the western Arctic.

Species of *Alcyonidium* seem to be given to unusual shapes but

perhaps the most amazing is that of *Alcyonidium disciforme* Smitt which has the shape of a convex washer. The largest colony measured 50 mm. in diameter, with the rim measuring 12 mm. in width, leaving the hole in the "washer" about 26 mm. in diameter. A colony 39 mm. in diameter had a rim 14 mm. wide. As the colony increases in size, the diameter of the hole in the center also becomes larger. This species was taken from muddy bottom from 10 to 80 feet. A few specimens came from Eluitkak Pass and one from 328 feet. Since the colonies are unattached, they are frequently washed ashore. They often have the firm gelatinous egg masses of some snail attached to them. This species was known previously only from the Kara Sea, and Wakeham Bay, Ungava.

The club-shaped *Alcyonidium pedunculatum* Robertson forms firm jelly-like colonies sometimes more than 100 mm. long and up to 15 mm. in diameter at the widest point. The cuticle is translucent brown and the zooids are a darker brown. Colonies came from Eluitkak Pass and from 110 to 162 feet, the latter through the ice on February 18, 1950, and were washed ashore during storms. This is the first record of this species since it was described from the Pribilof Islands in 1902.

Even more unusual than the above species was the new *Alcyonidium enteromorpha* Soule, which was collected on August 17, 1949, at 741 feet and on September 6, 1949, at 477 feet. It forms long, roughly cylindrical, gelatinous, unbranched, pale amber colonies without peduncles (in contrast to the above species). In both hauls these colonies of *enteromorpha* were so entangled with the tubes of the annelid *Pista maculata,* which made up the bulk of the haul, that it was impossible to remove one intact. Lengths up to 750 mm. were disentangled.

Flustrella corniculata (Smitt), which forms branching, fleshy colonies that are often covered with sand and debris, was common to abundant in hauls from 110 to 477 feet, the greatest number of colonies coming from 217, 328, and 453 feet. It is new to the western Arctic. The related *F. gigantea* Silen, new to the Arctic, was also taken at 217 feet.

Bowerbankia gracilis aggregata O'Donoghue, also new to the Arctic, was taken at Point Barrow.

Phylum ENTOPROCTA

Two species of this group were taken at Point Barrow. Both of these species had been known previously "only from Kluge's record (Drifting Ice Expedition in the central Arctic Ocean in the icebreaking Str. 'G. Sedov,' 1937-40)" (Osburn, 1953).

Beautiful and luxuriant colonies of *Barentsia gorbunovi* Kluge were dredged from depths of 120 to 477 feet. Colonies from 175 feet on October 14, 1949, had colonies of *Callopora spitzbergensis, C. craticula,* and *Tricellaria erecta* growing on them. An especially large colony came from 477 feet. The colonies resemble miniature bushes with white berries.

Coriella stolonata Kluge was collected at depths of 120 and 295 feet. The colony is smaller and less complex than the above species.

Phylum ANNELIDA

Class CHAETOPODA

Order POLYCHAETA

The polychaetes comprise an important group of the Point Barrow fauna. They were found in every zone from the gravel through the mud to the rubble, both as inhabitants of the substratum and as epifauna, and occasionally as planktonic forms. At two dredging stations, 477 and 741 feet, the hauls were made up largely of the terebellid *Pista maculata* in long, sinuous, and entangled tubes. Certain species, such as *Phyllodoce groenlandica* and *Autolytus fallax,* form an important source of food for other animals.

From the collection of 3,324 specimens of polychaetes Dr. Marian H. Pettibone identified 88 species, comprising 26 families. In this study she was able to reduce 49 species to synonymy, thus making a material contribution toward straightening out some of the great confusion into which the taxonomy of this group had fallen. One new species was described (Pettibone, 1951), and the results of the study of this group have recently been published (Pettibone, 1954). Eighteen of the 88 species are mainly Arctic, 30 are Arctic-Boreal, 18 are Arctic-Boreal-Lusitanian, 21 are cosmopolitan or nearly so, and 1 is bipolar.

Many specimens of the polynoid *Antinoë sarsi* Kinberg were collected but only four were dredged (from the mud zone). Another was taken through the ice in a trap on April 11, 1950, at a depth of 37 feet. Specimens up to 68 mm. in length were taken.

Like many polynoids, this species threw off its scales or elytra when it was disturbed and consequently successful preservation of the animal presented a problem. Various methods and many different anesthetics and preservatives were tried. A mixture of 5 parts of absolute alcohol to 95 parts of sea water, which is an effective and satisfactory anesthetic for most polychaetes, was only an irritant to *Antinoë sarsi.*

A method that proved successful with a polynoid from southern California that always broke itself in two when handled was then tried: the worm was laid on a paper towel until it became partly dry and inactive, when it could be placed in preservative without a casualty. *A. sarsi* could not be managed in this manner. Varying strengths of both hot and cold formalin and alcohol were tried separately and in combination, as well as in combination with other chemicals, without success. A quick flooding with boiling formalin was the most satisfactory method but this shrank the specimens considerably. Other methods, such as anesthetizing before placing the worm in preservative (provided the anesthetization was successful in the first place), sometimes gave promise of being successful. The elytra would stay in place for several hours—but then all of them would drop off.

As a last resort it was decided to try anesthetizing these worms with something to which they were already accustomed—cold. They were placed in a tray with barely enough water to cover them and put in the freezing compartment of a refrigerator. When ice formed, it was thawed slightly and the worms quickly placed in preservative. If only the water froze, the worm would be as lively as ever when the ice thawed, but if the worm became slightly frozen it could be placed in preservative without danger of the elytra's shedding. An attempt was made not to freeze the worm to the extent of damaging the tissues. This method of anesthetizing polynoids proved the most satisfactory one, even with those species that were less sensitive.

Without much doubt, *Antinoë sarsi* is commensal with the echiuroid worm *Echiurus echiurus alaskanus.* Both were washed ashore in large numbers during storms. The polynoid looks like a commensal form and it closely resembles *Hesperonoë adventor* (Skogsberg), which is commensal with the echiuroid worm *Urechis caupo* off the coast of California (MacGinitie, 1935). The writer often wished it were possible to dig the animals out of their burrows as easily as they can be dug from a mud flat. The copepod *Herpyllobius arcticus* was found on a specimen of *Antinoë sarsi* collected on August 21, 1949—a new host for this parasite.

The bright tan-colored polynoid *Arcteobia anticostiensis* (McIntosh) was taken from 148 to 741 feet. It is no doubt commensal with one of the terebellids, possibly *Pista maculata.* It is new to Arctic Alaska.

The large (60 mm. long by 23 mm. wide) *Eunoë nodosa* (Sars), undoubtedly a free-living form, was fairly common from depths of 110 to 522 feet. In life it is pale green and dull red, with reddish-brown tubercles on the scales. Like *Antinoë sarsi,* this species would

often submit to the usual anesthetization and preservation without shedding more than a few scales, but an apparently beautifully preserved specimen would subsequently be found without a single adherent scale.

Eunoë oerstedi Malmgren was taken at Eluitkak Pass and at 110, 175, 216, and 453 feet. *Gattyana ciliata* Moore was taken at 522, 453, 118, and 138 feet. The abundant tan to brownish *Gattyana cirrosa* (Pallas) was taken at Eluitkak Pass and at depths of 110 to 741 feet, with from 1 to 18 individuals per haul. Two were taken through the ice on February 18, 1950, at 162 feet. Three specimens were parasitized by *Herpyllobius arcticus*. *G. cirrosa* is new to Arctic Alaska.

One of the most abundant polychaetes in the dredge hauls was *Harmothoë extenuata* (Grube), which was taken at Eluitkak Pass and at depths of 125 to 741 feet. Specimens up to 70 mm. in length were taken, sometimes more than 50 per haul, but not all the specimens could be saved. They were found among bryozoans and hydroids, on rocks, and among masses of worm tubes, and were frequently hidden among the laminate growths of such bryozoans as *Bidenkapia spitzbergensis*. Each of two specimens from 217 and 125 feet had a female *Herpyllobius arcticus* on its head and one from 130 feet (September 15, 1948) had two. This species is new to Arctic Alaska.

Probably the most abundant polychaete in the dredge hauls was *Harmothoë imbricata* (Linnaeus), which was taken from Eluitkak Pass and in hauls from 70 to 741 feet. It seemed to be everywhere—among barnacles, bryozoans, old holdfasts of hydroids and tunicates, and around the bases of the octocoral *Eunephthya rubiformis*. There is great color variation in this species, the general effect being gray, but tan specimens and almost black ones are not uncommon. The scales were usually mottled with brown, black, or red, but the most distinctive pattern was one in which the black pigment was concentrated toward the inner half of the scales, producing the effect of a black stripe down the center of the back. Five specimens from Eluitkak Pass on August 6, 1948, were parasitized by 3 to 9 specimens of *Herpyllobius arcticus*. The one with the 9 copepods was only 38 mm. in length. This species is new to Arctic Alaska.

Most striking in appearance among the polynoids was *Melaenis lovéni* Malmgren with its small elytra which leave the center one-third of the back bare. About three elytra on one side and two on the other are black, the remainder of the scales and the body of the worm being pale gray. Only two specimens were dredged (from gravel bottom at a depth of about 10 feet) but they were common on

the beach after certain storms. One specimen collected on October 4, 1949, was a bright peach color from the tenth parapodium posteriorly. This color, due to eggs showing through, extended well out into the parapodia. The quick-freeze method of preservation was 100 percent effective with this worm. In the literature there is no record of this invertebrate from low water, where it obviously occurs at Point Barrow. Also, there is no mention of its being commensal, but the smooth scales suggest that it may be, and if it is, it may well be commensal with the lugworm *Arenicola glacialis,* which also lives near shore.

Thirty specimens of the sigalionid *Pholoë minuta* (Fabricius), up to 25 mm. in length, were taken from Eluitkak Pass and from 100 to 741 feet, and two from a screen trap at 37 feet on April 11, 1950.

Six species of phyllodocids that were new to Arctic Alaska were taken: 4 specimens of *Eteone barbata* (Malmgren) from Eluitkak Pass, 37 feet, and 162 feet; 23 *E. flava* (O. Fabricius) from depths up to 453 feet, all but one from stony bottom; 38 *E. longa* (Fabricius) from Eluitkak Pass and at depths of 110 to 453 feet and 2 from 10 feet from a small area of sandy-muddy bottom about 300 feet from shore (the latter were killed by the low salinity, 6.4 parts per thousand, of the surface water as they were brought up); 4 *E. spetsbergensis* Malmgren from 10 feet (sandy-muddy bottom—also killed by low salinity), 175 feet (April 11, 1950), 213, and 216 feet; 46 *Eumida minuta* (Ditlevsen) from 100 to 453 feet (28 specimens from the latter depth); and two very small specimens of *Mystides borealis* Théel from sessile animals on a small rock from 217 feet. *Eumida minuta* was known previously only from a few scattered records. Its abundance at Point Barrow indicates that it has probably been overlooked because of its small size, for it occurs among bryozoans and hydroids and growths on rocks.

The most abundant species of phyllodocid was *Phyllodoce groenlandica* Oersted, which was taken at Eluitkak Pass, from the beach after storms, and from 10 to 741 feet. Specimens up to 310 mm. in length were taken. This species also was killed when it was brought up through surface water of low salinity.

Twenty-seven specimens of the hesionid *Castalia aphroditoides* (O. Fabricius) were taken at Eluitkak Pass and from depths of 125 to 453 feet. An additional specimen, in the process of regenerating its posterior end, was taken through the ice on February 14, 1950, at 149 feet. White eggs, apparently ripe, showed through the integument of specimens taken on August 10, 1948. This hesionid was flesh-colored on the anterior end and parapodia but the central portion of

the body was green from the internal organs (not from eggs showing through). It is new to Arctic Alaska.

One of the most interesting worms was the syllid *Autolytus fallax* Malmgren, which ranged in length from 3 to 18 mm. The asexual or stem form was taken throughout the season of open water, sometimes on hydroids, bryozoans, or rocks, but often in tubes extending lengthwise along the hydroid *Lafoeina maxima*. In the asexual form the anterior portion of the worm was pale yellowish, with two dorsolateral longitudinal dark bands, and the posterior portion was orange. The female sacconereis stages bearing egg sacs were taken through the ice from January 25 to May 17, 1950. On March 29, 1950, there were hundreds of these worms, with egg sacs, swimming in the water at the 80-foot plankton hole and on April 7, 1950 (1.9 miles from shore) when the slush ice was removed from a 4-foot-wide lead, hundreds were welling up and swimming around. The worms were about 10 mm. long and the egg sacs 2.5 mm. long. Depending on the stage of development of the embryos, the egg sacs varied from a bright tan through flesh to a deep coral. The eggs contained enough yolk for the embryos to develop into small worms while still inside the sac. An occasional worm with two egg sacs was found. The manner in which these eggs become fertilized is not known.

Two other species of *Autolytus*—*A. prismaticus* (O. Fabricius) and *A. alexandri* Malmgren—not reported previously from Arctic Alaska, were taken, the former from Eluitkak Pass and from depths of 125, 175, 184, and 420 feet; the latter from depths of 100 to 741 feet. They are often found among hydroids and bryozoans.

The unusually large numbers of the species of *Autolytus* collected provided forms and sufficient material to enable Dr. Pettibone to clear up much of the confusion connected with the taxonomy of this group. (See "Reproduction Phenomena.")

Another abundant syllid, *Eusyllis blomstrandi* Malmgren, was taken at Eluitkak Pass and at depths of 80 to 741 feet, with the larger yields at Eluitkak Pass, 125, 140, and 175 feet. This luminescent species was common on hydroids, bryozoans, and masses of barnacles. The bluish-white light that it emitted when first brought to the laboratory aided materially in finding this small syllid, from 12 to 18 mm. long, among the growth on stones. This species is flesh-colored in life, with brownish-red eyes, and in an occasional individual there was a white stripe down the middle of the back. It is new to Arctic Alaska.

Other syllids new to Arctic Alaska were collected: *Eusyllis magnifica* (Moore) at 110 feet (September 16, 1948), both atokous and epitokous forms; *Exogone dispar* (Webster), 217 and 420 feet; *E.*

naidina Oersted from hydroids and bryozoans and on rocks from 100 to 741 feet (abundant at 453 feet); *Pionosyllis compacta* Malmgren from 216 and 477 feet (rare); asexual forms of *Sphaerosyllis erinaceus* Claparède from hydroids, bryozoans, and stones from 100 to 453 feet, and through the ice on February 14 and 18, 1950, and sexual forms at the 80-foot plankton station on March 29 and April 15, 1950. *S. erinaceus,* which is somewhat colorless to dusky, bears large rose-colored eggs on its dorsal surface between setigers 8 to 24, one to four per segment (125 feet on September 9, 1948). Another female (216 feet on October 6, 1949) was carrying large developing larvae attached to its dorsal surface.

Syllis cornuta Rathke, new to the western Arctic, was common in hauls from 125 to 741 feet, being most abundant in hauls from 217, 420, and 453 feet. The epitokous form with swimming setae was taken through the ice on February 14, 1950, at 149 feet, and on February 18, 1950, at 162 feet. Others were found swimming at the 80-foot plankton station on March 29 and April 15, 1950. The eggs are rose-colored.

Over 200 specimens of *Syllis fasciata* Malmgren, new to Arctic Alaska, were dredged from 110 to 741 feet, the largest numbers coming from 453, 175, 328, 217, and 741 feet. Two male stolons with swimming setae, not reported previously but since described by Pettibone (1954), were taken on March 29, 1950, at the 80-foot plankton station.

Two nereids were collected: *Nereis pelagica* Linnaeus, uniformly purplish or reddish-brown and iridescent in life, was taken from 110 to 522 feet, and *N. zonata* Malmgren, new to Arctic Alaska, was taken at Eluitkak Pass and at depths of 80 to 477 feet. Two specimens of the latter species taken on August 21, 1948, were purplish brown anteriorly and creamy tan posteriorly, the light color undoubtedly being due to eggs or sperm.

Four nephtyids were collected: The detritus-feeding *Nephtys ciliata* (O. F. Müller), 37 specimens from 28 to 453 feet; *N. discors* Ehlers, 4 specimens from 148, 213, 217, and 741 feet; *N. longosetosa* Oersted, 16 specimens from Eluitkak Pass, 10, 60, and 150 feet, and from the beach after a storm; and *N. paradoxa* Malm, 2 specimens from 141 and 741 feet.

A single specimen of *Glycera capitata* Oersted new to Arctic Alaska was taken on September 6, 1949, at 477 feet.

One goniadid, *Glycinde wireni* Arwidsson, represented by 5 specimens from 175, 138, and 162 feet, was collected. It is new to Arctic Alaska. One lumbrinerid, *Lumbrineris fragilis* (Müller) (29 specimens—deep flesh-pink in life and sometimes banded with brown),

and one orbiniid, *Scoloplos armiger* (Müller) (19 specimens), both new to Arctic Alaska, were taken.

Four species of spionids, all new to Arctic Alaska, were taken rather sparingly.

The cirratulid, *Chaetozone setosa* Malmgren, which is yellowish in life, was taken from 120 to 741 feet. It is new to Arctic Alaska. The more abundant *Cirratulus cirratus* (Müller) was dredged at Eluitkak Pass and from 80 to 453 feet. The integument of this worm varies from cream to yellowish but, with the red of the blood and the green of internal organs showing through, the general effect is a mixture of green, red, and cream; the cirri of the head are cream except where flushed with blood and the body cirri are also cream with two red lines caused by the flowing of two streams of blood. It is new to Arctic Alaska.

Nine specimens of the greenish-colored *Brada inhabilis* (Rathke) were dredged from 120 feet (September 15, 1948), 125, 453, 522, and 741 feet. Twenty-four specimens of the drab *Brada villosa* (Rathke), always somewhat covered with adhering sand, were washed ashore and two specimens were dredged from 175 and 162 feet. Nine specimens of *Flabelligera affinis* Sars were taken at depths ranging from 110 to 741 feet, and five washed ashore. In life this species is green, with a body so soft that it appears almost gelatinous. All these flabelligerids are new to Arctic Alaska.

A total of 17 specimens of the beautiful flesh-pink *Scalibregma inflatum* Rathke, new to Arctic Alaska, were collected. The largest ones, up to 100 mm. in length, were washed ashore on October 16, 1949. Four small ones were dredged during the summer of 1949, at 420, 175, and 477 feet. Fauvel (1927) states that this species is found in sand or mud at a depth of 12 to 24 inches. At this depth, only small specimens or larger specimens that were near the surface could be dredged from the sticky mud at Point Barrow. During the winter of 1950, eight specimens were dredged or taken with bottom samplers at depths of 138 to 185 feet, indicating that these worms had been washed from the muddy bottom nearer shore and then deposited with the mud at a greater distance from shore.

Two specimens of the whitish opheliid *Ammotrypane breviata* Ehlers, 6 to 7 mm. in length, were dredged, one at 217 feet, and the other at 175 feet. This worm had been taken from the South Orkney and Falkland Islands and from Kaiser-Wilhelm II Land, but there was only one other record (East Greenland) from the Northern Hemisphere. Another opheliid, *Travisia carnea* Verrill, new to Arctic

Alaska, washed ashore on October 17, 1949 (9 specimens), and August 10, 1950 (3 specimens).

Arenicola glacialis Murdoch is obviously very abundant for it washed ashore in great numbers after certain storms, especially in the open season of 1949. Two were dredged from the gravel near shore at a depth of 10 feet. This species is reddish, sometimes with a greenish prostomium and greenish caudal end. When preserved it often turns the preserving fluid a dark green and the worm itself becomes almost black.

Five species of maldanids, all new to Arctic Alaska or the western Arctic, and one new to Arctic America, were dredged. *Praxillella praetermissa* (Malmgren) was taken from seven stations in the mud-covered rubble zone in the fall and winter of 1949-50. Since it had not been taken in hauls from similar depths in 1948, it had obviously been transported to the rubble zone from the mud zone by the storms in the late open season of 1949.

Six specimens of the beautiful sabellariid *Idanthyrsus armatus* Kinberg, which is new to Arctic Alaska, were dredged from 28, 150, and 420 feet. The predominating colors are red and white, with golden setae on the head structures.

The cosmopolitan detritus-feeding *Sternaspis acutata* (Ranzani) appeared in the dredge hauls from 10, 132, and 148 feet.

Two species of pectinariids, both new to the western Arctic, were taken: *Pectinaria granulata* (Linnaeus) (53 specimens) from 22 to 741 feet; and *P. hyperborea* (Malmgren) (19 specimens) from 118 to 741 feet. Both were largely from stations characterized by mud bottoms.

Four species of ampharetids, three new to Arctic America and one new to Arctic Alaska, were dredged. The most interesting of these was *Asabellides sibirica* (Wiren) from 22 feet on July 26, 1948, (3 specimens). It lives in a mud tube with a tough lining. The tubes were from 100 to 140 mm. in length. One worm was 45 mm. long.

In number of species the terebellids equaled the syllids and polynoids, for each family was represented by 11 species. All the species of terebellids are new to Arctic Alaska and several are new to Arctic America.

A single specimen of *Amphitrite groenlandica* Malmgren was dredged from 295 feet and one specimen of *Leaena abranchiata* Malmgren was taken from 150 feet. *Amphitrite cirrata* Müller was represented by 14 specimens from 110 to 420 feet, 5 coming from 125 feet.

Lanassa venusta (Malmgren) was represented by 44 specimens from 110 to 453 feet, the 125-foot station yielding 10. This worm lives in a soft tube of mud cemented together with mucus, with a thin membranous lining, and with a small amount of sand and small pebbles adhering to the outside. The worm is pale peach below, somewhat darker above, with apricot tentacles tipped with red.

Seventy-nine specimens of *Nicolea venustula* (Montagu) were dredged from 80 to 213 feet, with 12 specimens coming from 125 feet. This worm lives in a tube of coarse sand attached to rocks. Fauvel (1927) states that it lives in a "thin tube of sand agglutinated to branches of algae or hydroids." In the absence of algae at Point Barrow, it apparently chooses the next best object for attachment.

By far the most abundant terebellid, and perhaps one of the most abundant polychaetes, was *Pista maculata* (Dalyell), which lives in long, cylindrical, membranous tubes with adherent foraminifers, small pebbles, and various kinds of debris. The bulk of the dredge haul from 477 and 741 feet was a mass of tubes of this species. The tubes were so long and so intertwined that it was difficult to disentangle them and it was still more difficult to remove a worm (up to 150 mm. when preserved) intact from its tube. Although 27 specimens of this worm were taken at 11 other stations from 125 to 522 feet (the most from any one station being 3), this species obviously prefers a soft, muddy bottom such as was encountered at 477 and 741 feet, for none was taken in the clayey mud zone.

Thirty-five specimens of *Polycirrus medusa* Grube were dredged from 80 to 477 feet. Six specimens from 125 feet were obtained by breaking apart the bryozoans *Bidenkapia spitzbergenis* and *Myriozoum subgracile*. Egg-filled females were reddish, but when the skin burst and released the eggs the worm became dark green.

Six specimens of *Proclea graffi* (Langerhans) were collected from 125, 217, and 216 feet.

Seven specimens of *Thelepus cincinnatus* (Fabricius) were dredged from 120, 125, 438, 477, 453, and 741 feet. The twisted, cylindrical tubes were associated with those of *Pista maculata* at 477 and 741 feet, and with the stems of the hydroid *Tubularia* at 120 feet. The hydroid in turn was associated with the mud-tube nests of the amphipod *Ericthonius tolli*. Sperm-filled specimens were apricot above and along the sides and white beneath, with bright-red branchiae and olive-apricot tentacles.

Eighty-seven specimens of *Terebellides stroemi* M. Sars, one of which was parasitized by the copepod *Saccopsis terebellidis*, were

taken. A few were washed ashore, 1 came from Elson Lagoon (7 feet of water), 13 were taken through the ice at 162 feet, and the remainder came from hauls from 110 to 741 feet.

Fifteen specimens of *Trichobranchus glacialis* Malmgren were taken at depths of 162 to 295 feet.

Seven species of sabellids, two new to the western Arctic and the other five new to Arctic Alaska, were taken: *Chone duneri* Malmgren (21 specimens) from 80 to 295 feet; the variable-colored *C. infundibuliformis* Kröyer (32 specimens) from 118 to 295 feet; *Euchone analis* (Kröyer) (3 specimens) from 216, 217, and 741 feet; *Myxicola infundibulum* (Montagu) (2 specimens) from 151 and 213 feet; *Potamilla neglecta* (Sars) (24 specimens) from 130 to 741 feet; *P. reniformis* (Leuckart) (15 specimens) from 130 and 328 feet; *Sabella crassicornis* Sars (15 specimens) from 217 to 741 feet.

The tubes of this group are unusually variable: *Myxicola infundibulum* lives in a tube of transparent, viscous mucus, so thick that it appears more like a mass of mucus than a tube. *Potamilla reniformis* lives in a horny tube with adherent sand, and the free end curls like a scroll when the worm draws inside. The Point Barrow specimens were in holes in rocks. *P. neglecta* lives in transparent horny tubes that are somewhat sand-encrusted. *Sabella crassicornis* lives in a cylindrical tube, the free end of which is grayish and flexible, and the embedded end transparent, rigid, horny, and covered with sand grains.

Potamilla neglecta retains its eggs within the tube until the larvae hatch. They are laid in a single layer on the wall of the tube about one-third of the way down; they are held in place by a thin, transparent membrane between the eggs and the worm.

Two species of serpulids, both new to Arctic Alaska and the western Arctic, were found. The sinistrally coiled tubes of *Spirorbis granulatus* (Linnaeus) were found on bryozoans, hydroids, and stones. Eggs were being incubated in the operculums on August 17, 1949 (741 feet) and on February 18, 1950 (162 feet). The dextrally coiled tubes of *Spirorbis spirillum* (Linnaeus) were found on the bryozoans *Porella compressa* (125 feet) and *Dendrobeania murrayana* (175 feet), and *Bidenkapia spitzbergensis* and *Dendrobeania murrayana* (184 feet), on bryozoans growing on the crab *Hyas coarctatus alutaceus* (175 feet), and on the spines of the tunicate *Boltenia echinata* (217 feet). Eggs were being incubated within the tube on September 29, 1948 (125 feet) and on August 30, 1949 (184 feet).

Class HIRUDINEA

Only one species of marine leech, *Crangonobdella murmanica* Selensky, was collected. Its host was the large shrimp *Sclerocrangon boreas* (Phipps). The writer is indebted to Dr. Marvin Clinton Meyer for identifying this leech. Although several species of fish, such as the Arctic cod and sculpins, that might be expected to harbor leeches, were taken, none was found on them. It is believed that marine leeches tend to drop from their hosts when the latter are drawn out of the water, which would account for their apparent scarcity.

Only three adult specimens of this leech were found: one unattached individual in a haul from 110 to 120 feet on September 15, 1943, that included a *Sclerocrangon boreas;* one from an ovigerous *S. boreas* that washed ashore on September 30, 1949; and another from the gravel nearby. *S. boreas* had numerous empty egg capsules of the leech attached to its pleopods. Another female shrimp from 110 feet (September 8, 1948) had a few empty capsules on its pleopods, and one that washed ashore on September 12, 1949, had over 50 egg capsules attached to its exoskeleton. A few of these were empty but the majority contained developing worms (one per capsule). Two female *S. boreas* taken on October 11, 1949, had on their pleopods a few capsules containing young leeches. These brownish, circular, convex, chitinous capsules, which are 1 mm. across, are attached to the host by an adhesive rim. They are blisterlike in appearance. The type specimens of *Crangonobdella murmanica,* described by Selensky in 1923, were taken from *S. boreas* off the Murman coast of Russia, northeast of the Kola Peninsula—on the opposite side of the Pole from Point Barrow—and no further record of the species has since appeared.

Phylum ECHINODERMATA

About 20 species of echinoderms were collected at Point Barrow: 6 asteroids, 8 ophiurans, 1 echinoid, and 5 (possibly more) holothurians. No crinoids were found in the area investigated. Most of the species were abundant, some of them exceedingly so, but, as is true of many species of echinoderms, some of them are gregarious or occur in patches, so that if they are taken at all they are taken in large numbers, unless the dredge happens to pass at the edge of the group. The writer is indebted to the late Austin H. Clark for identifying the echinoderms.

Class ASTEROIDEA

Fourteen species of starfishes have been reported from the eastern Arctic (from Greenland to the New Siberian Islands). Three of these, *Crossaster papposus, Solaster endeca,* and *Henricia sanguinolenta,* were found at Point Barrow. In addition, three species, *Leptasterias polaris* forma *acervata, L. groenlandica* forma *cribraria,* and *L. arctica* forma *arctica,* that are not known from the eastern Arctic were collected. These last three species are new to Point Barrow.

Thirteen specimens of *Crossaster papposus* (Linnaeus) were collected. About half of these were washed ashore at a small bight near the Point, and the others were taken at 125 feet, 120 and 130 feet (September 15, 1948), and 152, and 741 feet.

Five specimens of *Solaster endeca* (Linnaeus) (197 to 246 mm. in diameter) were washed ashore near the Point, and a small individual (85 mm.) was dredged at 420 feet. This is the first record from the western Arctic.

Two individuals (35 mm.) of *Henricia sanguinolenta* (O. F. Müller) were dredged at 125 and 741 feet, and one (50 mm.) washed ashore near the Point.

Nine specimens of the 6-rayed *Leptasterias polaris* (Stimpson) forma *acervata* Stimpson were collected: 8 from the shore near the Point, and 1 on the shore by the base. They ranged between 107 and 223 mm. in diameter.

Five individuals (from 12 to 32 mm. in diameter) of *L. groenlandica* (Lütken) forma *cribraria* (Stimpson) were dredged at 741 feet. Three specimens of *L. arctica* (Murdoch) forma *arctica* Murdoch were collected: one at 184 feet, one at 216 feet, and one from the beach.

Class OPHIUROIDEA

Of 10 species of ophiurans known from the eastern Arctic, 6 were collected at Point Barrow, two of them new to that area. Two species not known to the eastern Arctic were also collected.

Well over a dozen specimens of the basket star *Gorgonocephalus stimpsoni* (Verrill), the largest with a disk 75 mm. in diameter, were collected at 125 feet, 130 feet (September 15, 1948, and August 9, 1949), and 522 feet. One young one in the ophiocrenoid stage, arms forking only once, with a disk only 2 mm. in diameter, was taken at 125 feet. Two collected on August 9, 1949, with disks 17 and 21 mm., respectively, spawned freely in the laboratory. Swimming larvae developed.

Three small specimens of *Ophiacantha bidentata* (Retzius) were dredged at 175, 741, and 477 feet. The one from the latter depth was filled with eggs. This species is new to the western Arctic.

Collections comprising a few to large numbers of *Ophiopholis aculeata* (Retzius) were made from 110 to 741 feet, 20 to 30 specimens being obtained from 125, 130, and 217 feet. This species begins reproducing when it is less than half grown. From the well-filled condition of the gonads throughout August and the first week of September, it would appear that either spawning occurs after the first part of September or the eggs are retained until spring.

About 20 specimens of *Amphiodia craterodmeta* H. L. Clark were taken in 12 hauls from depths of 110 to 741 feet. Only one specimen was found well filled with eggs (on October 6, 1949). This is the first record from Arctic Alaska.

Over 100 specimens of *Amphiura sundevalli* (Müller and Troschel) were dredged from depths of 110 to 741 feet. They were found in interstices among other animals, often among the branches of the bryozoan *Myriozoum subgracile.* The condition of the gonads indicates that this species spawns during the latter part of August and in September. It is new to Arctic Alaska.

Ophiura sarsi Lütken was probably the most abundant of the ophiurans, but, since its habitat is a soft substratum beyond shallow water, it was limited to 477 and 741 feet in the area investigated. Evidence indicated that this species had spawned by the middle of August.

A single specimen of the circumboreal *O. nodosa* Lütken was dredged at 152 feet.

At least 70 specimens of *O. robusta* (Ayres), with disks from 2.9 to 10.8 mm. in diameter, were dredged at 16 stations at depths of 110 to 741 feet. Individuals with disks less than 5.5 mm. in diameter were juveniles.

Class ECHINOIDEA

Only one echinoid, *Strongylocentrotus dröbachiensis* (O. F. Müller), was found at Point Barrow, where it occurred at eight stations from 125 to 522 feet, being most abundant at 125 feet (approximately 175 specimens) and at 130 feet (September 15, 1948, 73 specimens).

Class HOLOTHUROIDEA

Two species of sea cucumbers that have been identified were exceedingly abundant; the three to five unidentified forms were seldom taken.

The mud-dwelling *Myriotrochus rinki* Steenstrup was taken at depths of 20 to 70 feet, and on several occasions hundreds were washed ashore during storms. This species ingests large quantities of mud for its contained detritus. Eggs appeared mature on August 10, 1950. In Greenland this species harbors a commensal snail *Entocolax ludwigi* within its cloaca. Although many specimens were examined, no snails were found in the Point Barrow *Myriotrochus.*

Psolus fabricii (Düben and Koren) was dredged from depths of 120 to 453 feet. As with the sea urchin, either very few or else large numbers of this animal were dredged. For example, 118 were taken at 125 feet, and 86 at 130 feet, 86 at 120 feet, and 170 at 110 feet on September 15, 1948. This is a detritus feeder. Spawning was not observed, nor were the gonads examined. The measurements of juveniles collected over a period of 2.5 months suggest that the species must spawn over a considerable period of time.

Phylum ARTHROPODA

Class CRUSTACEA

The crustaceans form a very important part of the fauna at Point Barrow for they are extremely abundant both as to species and individuals. They include pelagic and bottom-dwelling forms, both of which supply food for other animals.

Order OSTRACODA

The writer is indebted to Dr. Willis L. Tressler for supplying distribution data and identifying the members of this group, which consisted of 61 individuals and 5 species, each from a different genus. With the exception of those found on an amphipod, the greatest number—21 individuals, representing four of the genera and species—came from the station at 741 feet. This suggests that still deeper dredging might yield a greater population of ostracods than were found in the present investigation. Even at shallower depths, if special methods of collecting were employed, the yield in individuals at least, and probably in species, would be greater. Only 4 species of ostracods have been taken on the east coast of Greenland, as compared with about 50 from the west coast. This discrepancy in number of species may be due largely to differences in methods and intensity of collecting and perhaps to differences in sorting methods. Such small animals are easily overlooked.

A total of 19 specimens of the commonest and largest species at

Point Barrow, *Philomedes globosus* (Lilljeborg) were taken at seven stations from 125 to 741 feet, 13 from the latter depth. It is new to the western Arctic. One female of the almost cosmopolitan species *Asterope mariae* (Baird) was taken at 741 feet. Also new to the western Arctic, *Cytheridea punctillata* Brady, which is usually taken in depths of 35 to 125 feet, was taken at Point Barrow as follows: 175 feet, 1 female; 420 feet, 1 female; 741 feet, 5 specimens. *Cyprideis sorbyana* (Jones), new to the Pacific side of the Arctic, was taken as follows: 30 feet (mud), 1; 175 feet, 1 female; 741 feet, 2 specimens. Thirty specimens of the cosmopolitan genus *Paradoxstoma,* too immature to identify as to species, were found clinging to the medial side of the bases of the thoracic appendages and the ventral side of the thorax of an amphipod, *Gammaracanthus loricatus,* that washed ashore on October 4, 1949.

Order COPEPODA

The copepods are an important group in the economy of the sea. The pelagic species sometimes exist in such enormous swarms that they form a large part of the food of certain fishes and whales. They are also eaten by ctenophores and jellyfishes, and their larvae provide food for small organisms in the plankton. Although much less numerous than the pelagic species, the bottom-dwelling forms are fed on by other animals and their larvae furnish food for certain ophiurans and other strainers. The parasitic forms also affect other animals, albeit adversely. However, the larvae of even these forms must play their role in the feeding of certain animals. Of the 12 or 13 species of parasites collected at Point Barrow 8 or 9 were copepods.

The writer is indebted to Dr. Paul Illg for identifying many of the members of this group and supplying some of the distribution data.

Certain of the following species of Calanoida usually are not taken at the surface. Some of them were collected near shore following a storm and subsequent upwelling that brought deeper-water animals to the surface. Only surface plankton tows were taken at Point Barrow; no hauls were made at night.

The cosmopolitan *Calanus finmarchicus* (Gunnerus) and the circumpolar *C. hyperboreus* Kröyer were common in the plankton at Point Barrow. Both these species occur in deeper water in warmer seas (Jespersen, 1939). *C. tonsus* Brady, originally described from the Antarctic, *C. cristatus* Kröyer, *Xanthocalanus greeni* Farran, *Scaphocalanus magnus* (Scott), *Chiridius obtusifrons* Sars, *Metridia longa* (Lubbock), and *Heterorhabdus norvegicus* (Boeck), all ap-

parently new to Arctic Alaska, were also present. *Metridia longa* goes through a daily vertical migration, except during the season of long daylight, when it remains below the upper layers of water. In Scoresby Sund Fjord in east Greenland, *Heterorhabdus norvegicus* is believed to spawn in summer, for spermatophore-bearing females were collected in July and August (Jespersen, 1939).

Several unidentified bottom-dwelling species of copepods were so common that they deserve mention here. The one occurring in the greatest number of dredge hauls was a shield-shaped siphonostome, with spherical egg sacs containing a total of about 18 large apricot-colored eggs. Ovigerous females were found in August and October at 420 and 175 feet, respectively.

Another species, perhaps new, was common on the inner surface, especially of larger specimens, of the sponge *Echinoclathria beringensis* from Eluitkak Pass. About 50 percent of those collected on August 6, 1948, were ovigerous females. Among 35 specimens examined on August 1, 1950, there were 8 males, 14 females carrying eggs, and 3 females carrying young.

Copepoda Parasita

Herpyllobius arcticus Steenstrup and Lütken was found parasitic on four species of polynoids: 3 out of 375 specimens of *Harmothoë extenuata,* 13 out of 215 *H. imbricata,* 1 out of 63 *Antinoë sarsi,* and 3 out of 126 *Gattyana cirrosa. Antinoë sarsi* is a new host for this copepod and *Gattyana cirrosa* may also be a new one. This species of copepod occurs in east Greenland (Stephensen, 1912, 1943b), Iceland (Stephensen, 1940b), and west Greenland (Jespersen, 1939).

Saccopsis terebellidis Levinsen was found on 1 out of 87 specimens of the terebellid *Terebellides stroemi* Sars that were examined. It also occurs in west Greenland (Levinsen, 1878), east Greenland (Hansen, 1923; Jespersen, 1939; Stephensen, 1943b), west Iceland (Stephensen, 1940b), and in the Pacific (Wilson, 1935) with the same host but the specimen from Point Barrow forms the first record from Arctic America.

Several specimens of *Choniostoma mirabile* Hansen were found under the branchiostegites of the shrimp *Eualus gaimardi.* None of the copepods exceeded 3 mm. in length and one female was only 2.1 mm. long. They are cream-colored and bear cream-colored eggs (September 8, 1948; August 1, 1950). This copepod was described by Hansen in 1886 and reported by him from east Greenland in 1923. Stephensen lists it from the Kara Sea (1940b) and Davis Strait

(1943b) and reports it from Iceland on the shrimp *Spirontocaris lilljeborgi* and from east Greenland (1943b) on the shrimp *Eualus gaimardi.* The specimens from Point Barrow form the first record from America.

At least 10 specimens of *Schizoproctus inflatus* Aurivillius were taken from branchial baskets of the tunicate *Boltenia ovifera.* Of 90 *B. ovifera* examined from 175 feet on October 14, 1949, seven contained copepods measuring from 4.5 to 5.0 mm. in length and the bodies of the hosts (greatest dimension) were from 12 to 29 mm. Both larger and smaller tunicates were free of parasites. A 13-mm. *B. ovifera* from 341 feet contained a copepod, and two 35-mm. specimens from 453 feet each contained one. These two *B. ovifera* were from a cluster of 26 specimens in which the holdfasts and stalks were entwined. Although this copepod has been reported from Spitsbergen, northern Norway, west and east Greenland (Stephensen, 1943b) and Arctic Canada (Wilson, 1920), it is new to Arctic Alaska. In east Greenland it usually lives in a species of *Phallusia* (Stephensen, 1943b).

Specimens of a new species of *Dorypygus* were found in the branchial baskets of *Boltenia echinata:* two females (3.5 mm. long) with a large number of yellowish eggs (preserved) from 217 feet; one (4.5 mm. long) from 175 feet (October 14, 1949); and others. *B. echinata* is a new host and this genus of copepod is new to Alaska and Arctic America.

A large unidentified female copepod belonging to the family Enterocolidae was found by Dr. Donald P. Abbott among the unopened tunicates sent to him.

A single specimen of *Haemobaphes cyclopterina* (Fabricius) with a bright-red body 6.5 mm. long was taken from the gills of an Arctic cod, *Boreogadus saida,* that was brought in on June 21, 1950. The two cylindrical egg sacs, 6 mm. long, were white. Although this copepod is a well-known Arctic, subarctic, and north temperate species, it has not been reported previously from Arctic Alaska or from the Arctic cod as a host.

Order CIRRIPEDIA

Suborder Thoracica

Although only three species of this group were taken, they made up in number of individuals what they lacked in number of species. Dr. Dora Priaulx Henry identified these barnacles.

Balanus balanus (Linnaeus) was the least abundant. Specimens were taken at Eluitkak Pass and at 328 and 438 feet.

Next in abundance was *B. rostratus apertus* Pilsbry, which grows embedded in masses of sponge (see "Porifera"), with only the aperture open to the outside. A group of a dozen or more individuals growing one upon another may be surrounded by sponge. This barnacle was taken with *Topsentia disparilis* at 438 and 341 feet, and with *Myxilla incrustans* at 125, 328, and 217 feet.

Balanus crenatus Bruguière is one of the most abundant sessile animals in the waters off Point Barrow. It occurred in profusion at Eluitkak Pass and in all hauls from stony bottom from 110 to 522 feet. It was even found on mud bottom attached to snail shells and old clam shells. On August 3, 1948, a specimen attached to a snail shell had numerous tiny barnacles growing on it, and on August 30 a haul from Eluitkak Pass revealed new sets of young barnacles on everything to which they could attach—stones, shells, and even the isopods *Idotaega entomon* and *I. sabini*. Young from 1 to 1.5 mm. in diameter were abundant at 184 feet, and a young set was found attached to adult *B. crenatus* at 216 feet.

Order RHIZOCEPHALA

Two species of rhizocephalan parasites, identified by Dr. Edward G. Reinhard, were found. In both species the host is the pagurid *Pagurus trigonocheirus*.

One mature *Clistosaccus paguri* Lilljeborg was taken on a male pagurid at 438 feet; one very young specimen from a female pagurid at 217 feet, and another at 72 feet. The pagurid represents a new host and the copepods from Point Barrow extend the range northward from the 58th to the 71st parallel of latitude.

A single *Peltogaster depressus* Reinhard was taken from a male pagurid at 438 feet. Only two other specimens of this cirriped, both from *Pagurus capillatus* (Benedict), have been reported: one from off Kodiak Island, and one in the Bering Sea, taken by the *Albatross* in 1893 and 1897 (see Reinhard, 1944). *Pagurus trigonocheirus* therefore represents a new host, and the extension of range of the cirriped is the same as that of the above species.

Order MYSIDACEA

Only three species of mysids were collected. The writer is indebted to Dr. Albert H. Banner for identifying them.

Two ovigerous females of *Mysis oculata* (Fabricius) were taken

in a plankton tow on October 31, 1949, together with immature males and females about 15 mm. long (Banner, 1954). The eggs were 0.6 to 0.7 mm. in diameter. Very immature stages were taken on July 23, 1948, and immature males and females on September 1, 1949. Immature specimens of the *"relicta"* or brackish-water form of this species were taken on September 13, 1949, at Elson Lagoon where they occurred in great numbers along the shore, and again on July 28, 1950, near the Point, where they had washed ashore in such numbers that they formed rows along the beach. On September 30, 1949, there were swarms of this form near shore at the base, but all the 500 specimens, about 13 mm. long, that were collected were immature.

Four specimens of the bathyarctic *Boreomysis nobilis* (Sars) were taken near shore on September 27, 1948, when upwelling water brought them from deep water (see "Cephalopoda"). These extend the range of this species into the western Arctic. This mysid has beautiful, reddish, globular, luminescent organs that emit a blue light.

A single specimen of *Neomysis rayi* (Murdoch) was taken near shore on July 13, 1950.

Order CUMACEA

The strange creatures comprising this group look like the clowns of the crustaceans, but they are very retiring by nature and, instead of forcing themselves upon one's attention, the majority of them must be searched for. Although they appear to reach their maximum development in the Arctic, the largest known species, *Diastylis goodsiri* (Bell), does not greatly exceed an inch in length. Some of the larger ones at Point Barrow were white or cream beautifully marked with red bands, but the majority of the species were small and were an inconspicuous tan. A few specimens were found on the growth on rocks, but most of them were obtained by microscopic examination of the debris that collects in the bottom of jars containing unsorted masses of materials. Cumaceans live and feed on the mud and detritus of ocean bottoms, often at great depths. The peculiar shape of the forward part of the body may well be an adaptation fitting the animal for locomotion through the mud and detritus, functioning somewhat like a plowshare.

Nine species representing four families of cumaceans were collected. They ranged in length from 3.4 to 25 mm. For the identifications thus far received, the writer is indebted to Dr. Howard M. Feder, who expects to publish on this group.

Specimens of *Diastylis dalli* Calman were collected in 1948 at 110

feet and in 1949 at 120, 175, 184, 438, and 741 feet. The range was extended northward about 2 degrees. *D. bidentata* Calman was taken in 1949 at 120, 152, 216, and 295 feet and in 1950 at 204 feet.

Two species of *Diastylis,* both apparently new, were washed ashore during high surf in 1949. The single specimen of one of them was 25 mm. long.

Several specimens of species of the genus *Brachydiastylis* were collected in 1949 at 216, 477, and 741 feet. Only two species of this genus have been described. These above species show closest affinity to *resima* (Kröyer), which has not been reported from Arctic Alaska. A single specimen, only 7 mm. long, of a species of *Leptostylis,* probably new, was taken at 741 feet.

Specimens of *Cumella,* possibly *pygmaea* Sars, were collected at 184, 216, 217, 295, 438, 453, and 741 feet.

Two very small specimens of *Leucon,* possibly *nasicoides* Lilljeborg, were taken at 216 and 162 feet.

A single specimen, only 3.4 mm. in length, of a species of *Petalosarsia* was dredged on October 14, 1949, at a depth of 175 feet.

Order TANAIDACEA

Several specimens apparently all of one species, of the family Tanaidae, were collected at 80 feet, and several were dredged through the ice at 162 feet. These measured about 3 mm. long and were a glistening milk-white. They live on mud bottom and the best way to locate them in this sticky substance at Point Barrow is to place some of it in a pan and pour sea water over it. In time the tiny animals will find their way out of the mud and come to the surface of the water.

Order ISOPODA

For the identifications thus far made on this group the writer is indebted to Dr. Robert Menzies. About 11 species, representing 8 genera, 5 families, and 3 suborders were collected. The four or five species of Munnidae taken were not among those reported by Gurjanova (1933) from the Kamchatka Peninsula. The Point Barrow specimens must, therefore, either be new or else are the same as European Arctic species not well known in this country.

By far the most abundant species was *Idotaega entomon* (Linnaeus) (=*Mesidotea entomon* of authors). Over 250 specimens were counted and many others were collected for use by physiologists. The majority were taken at Eluitkak Pass, others along the ocean shore at a depth of 10 to 15 feet. This suggests that *I. entomon* prefers

shallow water and possibly water of low salinity; or it may be that it comes to water of low salinity to breed. Of those collected, the females outnumbered the males seven to one. For example, of 45 specimens collected on September 2, 1948, 14 were males and 31 females (4 ovigerous), and of 88 specimens collected on August 1, 1950, 1 was a male and the other 87 were females (4 ovigerous). The males averaged larger than the females: the largest male was 86 mm. long, the largest female 74 mm.

Ovigerous females were found as soon as the ice went out and until the water froze over in late fall. Females taken on July 13, 1950, had young isopods (from 482 to 776) in the brood pouches, and others taken on October 28, 1949, were carrying eggs only recently deposited. Eggs in the early stages are yellowish green and measure about 1.085 by 1.020 mm. The data collected suggest that in this species egg laying and development is continuous throughout the year. It may be of significance that this circumpolar species has not been taken in Greenland or Iceland. If brackish water is necessary for its existence, the proper conditions may be lacking in these two localities.

Idotaega sabini (Kröyer), less abundant than the above, also was taken only at shallow depths, largely at Eluitkak Pass and along shore. Of those collected, the males were about twice as numerous as the females. As in the above species, ovigerous females with eggs and brood were found early and late in the season. The males were larger than the females: the largest male was 85 mm., the largest female 68 mm.

Both of these species are unusually tolerant of fresh water and the former could not be killed by immersion in it. If not overcrowded, both species could be kept indefinitely in a cool place in finger bowls with only occasional changes of salt water.

One male and one ovigerous female of *Synidotea bicuspida* (Owen) were taken at 453 feet and a juvenile form at 741 feet. The female was carrying well-developed young. In life this species is tan with black eyes.

An ovigerous female of *Idarcturus* (?) *murdochi* (Benedict) ? was taken at 125 feet and a juvenile at 453 feet. This species, also, is tan with black eyes.

Thirty-eight specimens of a new species of *Janiralata,* including males, females, and juveniles, were taken from 120 feet September 15, 1948, to 741 feet. The animals are tan with a sprinkling of black pigment spots over the entire body.

At least two species of *Munna* were taken from 120 to 477 feet. One

female was carrying young on August 30, 1949, and another contained eggs in early stages of development.

Two species of *Pleurogonium,* represented by a single specimen each, were taken at 120 and 216 feet.

The parasitic *Phryxus abdominalis* (Kröyer) was found on the shrimp *Eualus gaimardi* (20 females and 1 male) and on *Spirontocaris phippsi* (1 male). About 5 percent of the *Eualus* taken from 215 feet were parasitized by this isopod. Immature specimens of the isopod were taken in August, October, and February, and females with eggs (yellow to dark yellow) on October 10 and 14, 1949.

Seven species of shrimps that are common hosts of *Phryxus abdominalis* were collected at Point Barrow, but only two of these were found parasitized, perhaps in some instances because too few specimens were collected. Stephensen (1943c) reports that the commonest host in east Greenland was *Lebbius polaris* and that only a few were found on *Eualus gaimardi,* but that the latter species was the common host in Iceland (1937a). This isopod is a circumpolar species but has not been recorded previously from Point Barrow.

Order AMPHIPODA

It would be impossible to overestimate the importance of amphipods in the Point Barrow fauna. They occur everywhere—in the plankton, and in the gravel, mud, and rubble zones. They are numerous, both as to species and individuals. That veritable swarms occur in the plankton is evidenced by the great numbers that were frequently washed ashore during storms (see below under *Themisto libellula* and *Melita formosa*). They form an important source of food for various fishes, for the bearded seals, and for many of the invertebrate forms such as ctenophores, jellyfishes, chaetognaths, and even other amphipods. Great numbers of the smaller *Apherusa glacialis* occur on the undersides of ice floes and cakes, from which the bearded seal can sweep them with its whiskers. On August 29, 1948, great swarms of this amphipod would dart away from the undersides of ice cakes when the latter were kicked.

With at least three species of amphipods occurring in such vast numbers that seals can grow and thrive on them, it would seem that they should form a source of food for military personnel forced to abandon ship or make a forced landing. *Apherusa glacialis* could be gathered with nets from the swarms that dart away when an ice cake is disturbed. Further research on the natural history of this group throughout the year could undoubtedly furnish information on ways and

means of obtaining amphipods in sufficient numbers to supply food for survival.

Since many of the amphipods cannot be identified in the field or even in the laboratory without painstaking dissection of minute mouth parts, it was impossible to keep as detailed collection data or natural-history notes as the writer wished. However, complete records were kept on the many species that are quite distinctive and easy to identify. As a rule taxonomists studying amphipods see only the preserved dead material, from which the color has completely faded or, at least, has changed. In working with the amphipods at Point Barrow it was noted that many of them have distinctive eye colors that fade out so completely in preservative that it is sometimes difficult to locate the eyes at all. The writer believes that by correlating adequate color notes on the living animal with subsequent determinations of other characteristics it would be possible in many instances to identify many of the amphipods by eye color without dissecting them.

The writer is indebted to Clarence R. Shoemaker of the U. S. National Museum for identifying the amphipods, which comprised about 100 species, including about 8 new ones (see Shoemaker, 1955).

The commensal phronimid *Hyperoche medusarum* (Kröyer) was not found associated with certainty with any particular species of jellyfish but was taken in plankton tows and from the beach. The closely related *Hyperia medusarum* (Müller) was much more abundant, and large numbers could be found on the beach when storms carried jellyfishes ashore. It appeared to be commensal with both *Chrysaora* and *Cyanea*. Evidence indicates that there are two or more generations of this species per year. The eggs, which are about 0.4 mm. in diameter, are white. Juveniles were taken on July 21, 1950. Dunbar (1942a) found this species, which is not often taken in the Arctic and is rarely found at the surface, less abundant in the Canadian eastern Arctic than *Hyperoche*.

The free-living, widely distributed Arctic phronimid *Themisto libellula* (Mandt) was extremely abundant, but during the summer of 1948 only a few were taken in plankton tows or picked up on the beach. By contrast, during almost the entire month of September 1949 *Themisto* was washed ashore, sometimes in such enormous numbers as to form rows along the beach for miles. On September 12, 1949, there were three rows of *Themisto* at distances of about 4, 6, and 15 feet above the waterline (see "Records of Surf Conditions and Shore Collecting"). At no time were ovigerous females found, but many newly molted specimens in which reddish-brown egg masses were visible through the integument were collected on the above date.

A female with a developing marsupium was taken on September 30, 1949.

Anonyx nugax (Phipps) was not observed at all during the summer of 1948 but was taken throughout the summer of 1949 and the winter of 1949-50. Never especially abundant except during the third week in September 1949, when thousands were thrown ashore, it was dredged from early August until October 14, 1949, at depths of 120 to 522 feet. In the winter and spring it was taken (by means of screen traps through the ice) regularly but sparingly except on February 28, 1950, when hundreds of small ones were taken, and on March 10, 1950, when both young and adults were numerous. One ovigerous female, with eggs 1.3 mm. in diameter, was taken on August 8, 1949, at 120 feet. Freshly molted females washed ashore on September 22, 1949, had well-developed ovaries that showed through as peach or orange masses, and several females between 32 and 37 mm. long had developing marsupiums. This species is new to Arctic Alaska.

An ovigerous female *Paronesimus barentsi* Stebbing washed ashore on October 5, 1949, and another taken on August 21, 1949, had, in addition to three young amphipods, a male and female copepod in its marsupium. This species has been known only from west of Nova Zemlya.

Several species of *Pseudalibrotus,* difficult to distinguish because of their similarity and small size, were taken. *P. birulai* Gurjanova, which has reddish-brown eyes, came from plankton tows and the fine gravel near shore. *P. littoralis* (Kröyer), a pale-gray species with cerise eyes and coral-colored eggs, may be found in the gravel near shore, where it goes in and out of the interstices, feeding voraciously on any disabled animals that it can find, such as arrow worms, shrimps, amphipods, and even fish. It is a hardy species that can survive low salinity and abrupt changes of temperature.

The only specimen of *Onisimus normani* Sars collected was an ovigerous female from 60 feet. This amphipod was pinkish white, and the large, oval eggs were orchid color, turning yellow in preservative.

Onisimus affinis Hansen was dredged from 120 to 438 feet, taken through the ice on March 9, 1950, at 135 feet, and in a fish trap on February 7, 1950, at 7 feet. In the latter specimen the ostegites and thoracic appendages were translucent white, the caudal appendages and the thorax and abdomen pinkish buff, and across the posterior margin of each segment was a transverse band of bright orange red. The antennules were tinged with the same color and the eyes were a shining orange red. A specimen that washed ashore on September 19,

1949, was duller in appearance and was without the transverse bands. Two females had parasitic copepods in their marsupiums.

Three species of *Orchomenella,* difficult to distinguish after preservation, could undoubtedly be identified in life by eye color. *O. groenlandica,* a small white amphipod with large, oval, black eyes, was taken sparingly. *O. pinguis* (Boeck), a small, white amphipod with red eyes, was abundant. An ovigerous female with pale orchid eggs was taken through the ice on January 27, 1950, at 37 feet. *O. minuta* (Kröyer) was taken at Eluitkak Pass and at depths of 80, 120, 135, 152, and 741 feet. All are new to the western Arctic.

Socarnes bidenticulatus (Bate) was dredged from 175 to 453 feet. A female from 453 feet was carrying eggs in a medium-early stage of development and one from 175 feet was carrying young embryos. Ovigerous females were taken in east Greenland (Stephensen, 1944) from July 30 to August 18, 1933, down to about 95 feet. In life this species is a beautiful mixture of maroon and white, with black eyes.

A single ovigerous female *Tryphosa triangula* Stephensen was taken from a fish trap at a depth of 33 feet on January 27, 1950. It was pale flesh color, with translucent white appendages. The eggs were a bright maroon.

A specimen of *Stegocephalus inflatus* Kröyer was taken at 138 feet and an ovigerous female at 130 feet (August 9, 1949). The latter was tan on a whitish background with an olive-green cast.

A female *Stegocephalopsis ampulla* (Phipps) 39 mm. long and with a marsupium was taken at 125 feet. This large amphipod is cream-colored, with a dark dot at the lower edge of each thoracic segment. Although rather widely distributed in the Arctic, apparently it is not abundant, for it was found only once at west Greenland and three times in Baffin Bay (Stephensen, 1944).

Two specimens of *Ampelisca eschrictii* Kröyer, including a female 37 mm. long with ovaries full of well-developed eggs, were found (August 21, 1948). This species is white, with orange-red and dull-orange markings, four maroon eyes, and a reddish mouth region.

Ampelisca birulai Brüggen was collected from 80 to 216 feet. A female from 216 feet was carrying 14 or 15 eggs about 0.8 mm. in diameter that were in early stages of development.

Byblis gaimardii (Kröyer), a common and conspicuous amphipod, was taken from depths of 80 to 420 feet. Pinkish or pale-salmon color, with both black and chalk-white pigment "stars" on the head region of the carapace and white pigment stars on the terminal half of the first ostegites, and with four red eye spots (that turn black in preservative), it is easily distinguished in the field. The eggs,

which are about 0.8 mm. long, are bright maroon. This species builds mud tubes in colonies, the tubes of adults being about 50 mm. long and 12 mm. wide with no constriction at the opening. Any one haul may bring up both large and small individuals, from 5 to 19 mm., for example. The Point Barrow specimens form the first record from the western Arctic.

Haploops laevis Hoek was present, and occasionally abundant, in hauls from 118 to 741 feet. The body is whitish and the small eyes are a bright cerise, which fades out completely in preservative. Below each eye and slightly anterior to it is a cerise spot that at first glance resembles another eye. There are no black pigment spots around the eyes as in *Byblis gaimardii.* The eggs are clear with a small orange-red spot at the pointed end and a larger orange-red spot toward one side and the larger end. *Haploops laevis* also builds mud tubes in colonies. The tubes of adult animals are about 50 mm. long and 12 mm. in diameter and are sometimes constricted at the top. In one dredge haul made through the ice on February 18, 1950, 14 specimens from 3 to 19 mm. in length were collected. This species is new to Arctic America.

Pontoporeia femorata Kröyer was taken at 477 and 741 feet where the bottom is characterized by a mud softer than that of the mud zone. Forty-eight specimens were picked up from the beach from September 22 to 26, 1949. This species is oyster white with whitish, opaque eyes, more suggestive of tumors than eyes, that sometimes have pink spots scattered over the surface. The eggs are salmon-colored. This is abundant in Iceland (Stephensen, 1940a). It is new to Alaska and the western Arctic.

A few specimens of *Gitanopsis arctica* Sars, a small species with a creamy-white body and round brown eyes, not previously reported from Alaska and the western Arctic, were taken at 125, 175, and 216 feet.

Thirty specimens of *Acanthonotozoma inflatum* (Kröyer), a small white species with tan showing through, and with round brown eyes, were taken from 150 to 420 feet.

Eight species of *Metopa,* one of which was new and the other seven of which were new to Alaska, were collected: *M. clypeata* (Kröyer), 50 specimens from Eluitkak Pass and depths of 120 to 477 feet; *M. glacialis* (Kröyer), 4 specimens from 477 feet; *M. bruzeli* (Goës), 16 specimens from 80 to 453 feet; *M. longicornis* Boeck, 34 specimens from 60 to 295 feet; *M. spinicoxa* Shoemaker, n. sp., 52 specimens from 60 to 184 feet; *M. tenuimana* Sars, 11 specimens from 80 to

184 feet; *M. propinqua* Sars, 1 specimen from 110 to 125 feet; *M. robusta* Sars, 3 specimens from 175 to 216 feet.

Also forming first records for Alaska were *Metopella nasuta* (Boeck), with 1 specimen from 341 feet and 1 from 741 feet, and *M. longimana* (Boeck), with 1 specimen from Eluitkak Pass and 40 from depths of 100 to 341 feet.

Ten specimens of *Mesometopa neglecta* (Hansen), also new to Alaska, were collected from 80 to 216 feet, and 19 specimens of *M. gibbosa* Shoemaker, n. sp., were taken from 80 to 420 feet.

Two specimens of *Stenothoë barrowensis* Shoemaker, n. sp., were collected at 341 feet, and 19 specimens of *Stenothoides angusta* Shoemaker, n. sp., were dredged from 100 to 216 feet. *S. barrowensis* is a translucent white species with a translucent grayish-tan dorsum and almost transparent appendages and shining orange-red eyes.

Ten specimens of *Proboloides nordmanni* (Stephensen) were collected from 80 to 217 feet. This species formerly was known only from a single female taken from the southwest coast of Greenland.

Two species of *Metopelloides,* both new to Alaska and the Arctic, and each forming the second record of its occurrence, were collected: 1 specimen of *M. tattersalli* Gurjanova came from 341 feet; 5 specimens of *M. stephenseni* Gurjanova from 5 to 5.5 mm. in length came from 120 to 217 feet. Even though it is small, the latter is a beautiful and conspicuous species. The main portion of the body and the appendages are either transparent or else translucent white. Just posterior to the head there is a broad transverse band of bright reddish orange that extends to the tips of the ostegites, and another broad band of the same color extends across the posterior portion of the thorax. The small round eyes are of the same bright color, but have a more shining and metallic appearance. This species is new to America and the western Arctic.

About 25 specimens of *Acanthonotozoma serratum* (Fabricius) were dredged from 125 to 216 feet. This species is beautifully colored with almost round, white eyes. The body in some specimens is irregularly striped transversely with orange red and white or with pinkish red and white; in others it is almost a solid pink or peach color with the tail portion white. No two color patterns are exactly alike. The color fades out completely in preservative. This species is new to Alaska and the western Arctic.

A few specimens of *Acanthostepheia malmgreni* (Goës), new to Arctic Alaska, were washed ashore. *Acanthostepheia behringiensis* (Lockington) was obtained chiefly from specimens washed ashore, but it was dredged also at Eluitkak Pass and alongshore in water from

10 to 15 feet deep. This species is gray above, with sometimes a suggestion of tan, and light beneath, and the eyes are black. It is new to Alaska and Arctic America.

Seven specimens of *Monoculodes borealis* Boeck were washed ashore on September 22, 1949. This species is whitish, and the large, single, shining eye, situated toward the tip of the long rostrum, is a pale-peach color. Three specimens of *M. latimanus* (Goës) were dredged from 110, 120, and 741 feet. This species varied from cream to pinkish white. A few specimens of *M. schneideri* Sars were also found. An ovigerous female *M. packardi* taken at 80 feet on March 29, 1950, was transparent pale orchid and the eggs were a transparent greenish. The eye, similar to that of *M. borealis* but nearer the tip of the rostrum, was much larger in proportion to the size of its body than that of *M. borealis*. All four species are new to Alaska.

Two specimens of *Aceroides latipes* (Sars) were taken at 80 feet on March 29, 1950. They were translucent white except for the distal ends of the appendages, which were lavender.

Three specimens of *Syrrhoë crenulata* (Goës) were taken at 216 feet. The body was transparent with a few splotches of orange red and with large reddish-peach eyes shining like a headlight at the very top of the head. This species is new to the western Arctic.

Apherusa glacialis (Hansen) was one of the abundant species at Point Barrow, where it was found chiefly under ice cakes (see introductory remarks on the "Amphipoda"). This pelagic arctic species is circumpolar in distribution. Stephensen (1944) reports it from east Greenland from the stomach of a seal, a young *Phoca foetida*, and Dunbar (1942a) has reported it in plankton from east and southeast Baffin Island, and from the stomach of *Phoca hispida*. The amphipod is grayish white and the round, rather large eyes are dark.

A female *Pleustes panoplus* (Kröyer) was dredged at 80 feet and an ovigerous female was taken in a screen trap on March 10, 1950, at 37 feet. The eggs, which were in the two-celled stage, were a translucent yellow orange averaging 788 microns in diameter, including the membrane. The dorsal portion of the body of the amphipod is a splotched, mottled, and speckled effect of pale brown, reddish brown, brown, red, and chalk white. The ostegites and rostrum are mainly olive and gray with chalk-white spots and a little red. This is the first record from Alaska. A few specimens of *Pleustes medius* (Goës), also new to Alaska and the western Arctic, were taken at 217 to 420 feet.

Sympleustes pulchellus (Sars), new to the western Arctic, was taken sparingly at 125, 438, and 453 feet, and *S. kariana* Stappers,

known only from the Kara Sea, was dredged at 110 and 175 feet. The more abundant *S. uncigerus* Gurjanova was taken from 60 to 477 feet. The highest yields (a total of 107 specimens) came from 125, 175, 184, and 216 feet (September 15, 1948) by breaking apart such bryozoans as *Bidenkapia spitzbergensis* and *Myriozoum subgracile.* The body of this amphipod is white and the large oval eyes are dusty rose. The eye color is retained in preservative for a few months but it may change to reddish brown or pink. This species has been reported previously only from the tidal zone in the Sea of Japan.

About 12 specimens of *Paramphithoë polyacantha* (Murdoch) were taken from Eluitkak Pass, from the beach, and from depths of 130 to 420 feet. This is a large, bright red-and-white species, with dorsal and lateral spines. The males averaged smaller than the females: the largest male was 22 mm. long, the largest female, 35 mm.

Atylus carinatus (Fabricius) was collected sparingly at Eluitkak Pass and at about 10 feet along shore. This species, new to Alaska and the western Arctic, occurs in Greenland mainly with *Laminaria* and other algae (Stephensen, 1944). Except at certain areas of Elson Lagoon, such algal growths are lacking at Point Barrow. Careful collecting at Elson Lagoon might yield more of this species.

Eusirus cuspidatus Kröyer, new to Alaska, was a colorful and common species in all hauls from 125 to 741 feet. It is reddish brown to dull orange on a cream background, with dull orange-brown bands on the antennae, and with crimson, bean-shaped eyes. Males from 25 to 38 mm. and females from 23.5 to 47 mm. were collected. Juveniles from 2 to 8 mm. were taken at 125, 246, and 175 feet.

Rhachotropis aculeata (Lepechin), new to Alaska and the western Arctic, was taken at 80 to 328 feet. It is a colorful red-and-white species with no two color patterns alike. Males were from 22 to 24 mm. and females from 23 to 39 mm. in length.

Four specimens of *Rozinante fragilis* (Goës), new to Alaska and the western Arctic, were taken from the stomach of an Arctic cod (*Boreogadus saida*) that was caught in a fish trap on February 3, 1950, at 21 feet.

A few *Weyprechtia pinguis* (Kröyer) were dredged at Eluitkak Pass and at 80 feet. Several *W. heuglini* (Buchholz) were dredged from the mud zone at 80 feet on July 21 and September 9, 1948. Several were washed ashore, and 3 females were taken through the ice on June 23, 1950, at 37 feet. Two of these females, measuring 43 mm. in length, were developing marsupiums and were filled with oil. Both these species are new to Alaska and the western Arctic, and the latter to Arctic America.

Although only two specimens of *Melita formosa* Murdoch came in with dredge hauls, countless numbers washed ashore (see "Records of Surf Conditions and Shore Collecting"). This species is dull orchid in color. In seven ovigerous females the number of eggs ranged between 44 and 81, but the majority were carrying 54, averaging 0.7 mm. in diameter.

In contrast to the above species, only one specimen of *Melita dentata* (Kröyer) was picked up on shore, but from 1 to 16 or more individuals appeared in all dredge hauls from 80 to 453 feet. This species, which is new to Alaska and the western Arctic, is also dull orchid, with blackish-brown eyes. No ovigerous females were found.

Never especially abundant, *Maera danae* (Stimpson) was present in dredge hauls from 80 to 477 feet. It has dark eyes and a pale yellowish-red or pale-orchid body and appendages. The eggs, which measure about 0.8 mm. in diameter, are clear with yellow spots. The entire egg turns yellow in preservative.

Two specimens, a male 33 mm. long and a female 32 mm. long, of *Gammarus locustus* (Linnaeus) var. *setosus* Dementieva appeared in a dredge haul from 120 feet (September 15, 1948), but all the other specimens came from Eluitkak Pass or from shallow water along shore. It is no doubt abundant in favorable localities in Elson Lagoon. Males up to 51 mm. and females up to 32 mm. were taken. This species is somewhat variable in color but is predominantly grayish. Young or freshly molted specimens may be almost translucent white. The tips of the thoracic appendages, the antennular flagellae, and the third joint of the antennal peduncle are reddish brown. The small, bean-shaped eyes are black. This species, which is new to the western Arctic, is a hardy form that can tolerate adverse conditions and considerable dilution with fresh water.

Gammaracanthus loricatus (Sabine) was taken at Eluitkak Pass, in 5 feet of water at Elson Lagoon, and alongshore in from 10 to 20 feet of water. The largest male measured 45 mm. in length, the largest female 53 mm. Two small bivalves and an ostracod were attached to one 40-mm. female from Eluitkak Pass (August 1, 1950). This amphipod is gray and white or tan and white above, with the color so arranged that it forms longitudinal lines down the back. The appendages are white with tinges of gray or tan, and the basal half of the distal segment of the three long legs is a deep maroon. The antennules are banded with tan or maroon. The eyes are a shining, pinkish salmon. This is also a hardy species that is tolerant of adverse conditions and great changes in salinity.

About 40 specimens of *Photis reinhardi* Kröyer were taken at

depths of 110 to 741 feet, with the highest yield (25) from 453 feet. Males up to 5.2 mm. long and females up to 5.5 mm. were taken. Juveniles from 1.5 to 2.0 mm. long were taken at 453 and at 162 feet. This species has a shiny, brownish-gray body, with small, oval, dark eyes. From 5 to 14 white eggs, measuring 0.5 mm. in diameter, were counted from ovigerous females from 4.5 to 5 mm. long. This species is new to the western Arctic.

Eurystheus melanops Sars, also new to the western Arctic, was taken in most hauls from 110 to 741 feet. Males up to 9 mm. were taken, and juveniles were collected on August 30 and October 11, 1949. The upper portion of the body is pale gray, the remainder transparent, and the large, round eyes are black. From 3 to 18 eggs, 0.4 to 0.5 mm. in diameter, were taken from females from 3.5 to 14 mm. in length. The eggs were white or cream or yellow. This variation in the color may be due to the stage of development, but the variation in length of the females suggests either that they begin reproducing at an early age or that two species are represented.

One male and two ovigerous females of *Protomedeia fasciata* Kröyer were dredged at 80 feet and numerous specimens from 7 to 8 mm. in length were taken at 110 feet (September 8, 1948). The body of this species is marked with grayish brown or gray on a whitish background, and the eyes are black, with the facets outlined in white. The eggs are purplish blue. A few specimens of *Protomedeia grandimana* Brüggen were also collected. Both species are new to Alaska and the western Arctic. Eleven specimens of a new species, *Protomedeia stephenseni* Shoemaker (1955), washed ashore in August and September 1950.

No haul from 80 to 741 feet was without *Ischyrocerus latipes* Kröyer, sometimes so numerous that only a few representative specimens could be picked out and preserved. The largest were about 17 mm. long. Juveniles were taken throughout the open season. This species is usually marked with silvery gray on a lighter background, but some individuals have purplish-brown markings and others are tinged all over with dull rose orchid. The small, nearly round eyes are black in the center with reddish brown around the periphery. Juveniles are grayish white. Embryos are white, with a speck or two of red. A female 12 mm. long from 453 feet had parasitic copepods and their egg sacs in the posterior half of her marsupium, and another female had parasitic copepods and egg sacs filling the entire marsupium. This amphipod is apparently new to Arctic America.

The less conspicuous *Ischyrocerus commensalis* Chevreux (up to 5 mm. in length) was in hauls from 110 to 453 feet. This amphipod

is whitish with gray-brown markings that turn reddish brown in preservative. The large round eyes are reddish brown. One female from 184 feet was carrying 15 eggs about 0.5 mm. in diameter. This species is new to the western Arctic.

Ericthonius hunteri (Bate) was one of the very abundant species in hauls from 125 to 216 feet. It builds masses of mud-tube nests several inches in height. The animals are gray with two bands of color around the antennae and antennules: in the young these bands are red and in larger specimens they are purplish brown. This is the first record from Arctic America.

Ericthonius tolli Brüggen, a colorful species that came from 125 to 477 feet, also lives in colonies of mud tubes. The body is dull orange red and white and the flagellae of the antennae and antennules are golden tan. Freshly deposited eggs are purplish pink.

About seven specimens of the bizarre *Dulichia spinosissima* Kröyer were taken from the beach or through the ice by means of screen traps or dredging. One ovigerous female (March 10, 1950) was carrying 227 white eggs in about the morula stage. Five eggs that were measured averaged 522 microns in diameter. This species varies from almost translucent white to pale tan. There is a band of reddish tan at the distal end of the second and the basal end of the third joint of the antennal and antennular peduncles. The whitish specimens have a few minute chalk-white and reddish-tan specks scattered over the body. The eyes are whitish with a little color toward the center. This species is also new to the western Arctic.

Dulichia arctica Murdoch and *Dulichia porrecta* (Bate) were also collected sparingly up to depths of 184 and 213 feet, respectively. The latter species has gray-brown markings on the body. The eggs are white.

Order EUPHAUSIACEA

In view of the fact that the collection of planktonic organisms was only incidental, it is not surprising that only three species of euphausiids were found. The writer is indebted to Dr. Albert H. Banner for identifying these (Banner, 1954).

Eight specimens of *Thysanoëssa raschi* (M. Sars) were taken in plankton tows near shore, one washed ashore, and one was taken from the stomach of a Sabine's gull. This is an Atlantic-Arctic-Pacific species. At Bernard Harbor it was found in the stomachs of the seal *Phoca hispida* and the fish *Salvelinus malma* (Schmitt, 1919). Dunbar (1942a) reported it from seal stomachs at Lake Harbor, eastern Canada.

About 25 specimens, mostly immature, of *Thysanoëssa longipes* Brandt were washed ashore and 2 specimens were taken in a plankton tow near shore on July 20, 1950.

Four specimens of *Thysanoëssa inermis* (Kröyer) were taken from the gullet of a Sabine's gull at Elson Lagoon on August 26, 1950, and one was taken in a plankton tow on July 20, 1950. This is the first record from the western Arctic.

Order DECAPODA

A total of 21 species of decapods—2 hermit crabs, 3 true crabs, and 16 shrimps (9 genera)—were collected. These were obtained by dredging only, for no special techniques or nets adapted to the taking of shrimps were used. I am indebted to Dr. Fenner A. Chace, Jr., for identifying a representative lot of decapods, and to my wife, Nettie MacGinitie, for identifying subsequent collections.

It is worthy of mention that all but four species of the decapods were a combination of red and white. One of the four species was chiefly an olive tan, one was a black-and-white mixture, and two were predominantly translucent green. At least at certain seasons of the year, even these two latter species had red markings. At the depth at which these decapods occur, the red color would be screened out and these red-and-white decapods would appear as black and white.

A single male specimen of *Pandalus borealis* Kröyer was collected on September 9, 1948, at 110 feet. This species is very common in Iceland, where it forms an important part of the food of the cod. Its wide distribution in cold north Atlantic waters, Spitsbergen, the Barents and Kara Seas, and the east coast of North America, together with the fact that the shrimp is not a littoral species, suggests strongly that collecting methods adapted to the taking of shrimps would show this species to be common at Point Barrow.

Eight specimens of *Spirontocaris arcuata* Rathbun, ranging in length from 38 to 54 mm., were dredged from six stations from 110 to 453 feet. The usual color of this animal is a mixture of red with chalk white and translucent white, but specimens in which the entire carapace is chalk white and the abdomen and appendages are entirely red are also found.

Ten specimens of *Spirontocaris phippsi* (Kröyer) were taken from five stations from 125 to 217 feet. They ranged in length from 19 to 35.5 mm., exclusive of the rostrum. One of the males was parasitized by *Phryxus abdominalis*. This species is a mixture of red and chalk white. The eggs are green.

Thirteen specimens of *Spirontocaris spina* (Sowerby), ranging from 25 to 57 mm. in length, were taken at 10 stations from 110 to 453 feet. This species is red and white with a few olive-tan spots and a few chalky-white streaks. The eyes are black. Heegaard (1941) found no more than two or three specimens per haul of this species around Greenland. It was always taken where *Balanus porcatus* occurs, for the shrimp hides among the barnacles. *Balanus crenatus* may form the refuge of this shrimp at Point Barrow. *S. spina* is new to Point Barrow.

The shrimp that was taken in the greatest numbers at Point Barrow was *Eualus gaimardi* (H. Milne-Edwards). The majority of the specimens were undoubtedly of the forma *belcheri*. There was considerable variation: several females were found in which the third abdominal segment terminated in a spine like that of the male, and several males were found in which the spine on the third abdominal segment was lacking; and there was variation in the relative proportions of the antennular palp and the antennal scale. This animal was parasitized by the isopod *Phryxus abdominalis* and the copepod *Choniostoma mirabile*. It is chiefly transparent pale green with markings of red. The eggs are green. Although this is an Atlantic-Arctic-Pacific species, it has not been reported previously from Arctic Alaska.

A few specimens of *Eualus fabricii* (Kröyer) were taken at 110 and 175 feet and one male of *Eualus macilentus* ? (Kröyer) at 175 feet. Five specimens of *Eualus suckleyi* (Stimpson) were taken from 125 to 741 feet. One female was fairly transparent, with reddish orange in the hepatic region, and an ovigerous female was translucent white with red markings.

Three specimens of *Lebbius polaris* (Sabine) were taken at 110 and 125 feet. Hofsten (1916) found that at Spitsbergen the size of this species increases with the increasing depth of its habitat, but Heegaard (1941) did not find this to be the case with the specimens from east Greenland. In Greenland egg-bearing females of this species were found in December, January, February, April, June, July, and August.

Two specimens of *Heptacarpus flexus* (Rathbun) were taken at 110 and 215 feet. This shrimp has a white body with red markings. In early stages of development the eggs are yellowish cream.

One male *Crago communis* (Rathbun) measuring 60 mm. in length was washed ashore on September 12, 1949. It has not been known north of Bering Strait previously.

Seven specimens of *Sabinea septemcarinata* (Sabine) were taken at four stations from 110 to 420 feet. The dorsal surface of this species has fuzzy-edged brown pigment spots resembling tufts of

moss, and a few yellowish-green pigment spots. The under surface is light with a few red and reddish-orange spots, especially on the legs. The eyes are green.

The fairly large shrimp *Argis lar* (Owen) was taken at four stations: Elson Lagoon and at depths of 60 to 110 feet. One ovigerous female was taken on September 8, 1948. The eggs of this species are large (1.5 to 2 mm. in diameter) and Stephensen (1916) believes that the larvae leave the egg at a very late stage of development. Free-swimming larvae have been found only in stages that are almost postlarval.

Although no one haul brought up more than four specimens, *Sclerocrangon boreas* (Phipps) was the largest and most abundant of the larger shrimps taken at Point Barrow. Its slowness of movement probably accounts for the frequency with which it was taken. A total of 16 males, 7 nonovigerous females, and 2 ovigerous females was taken. A few washed ashore, 4 males were taken at 453 feet, 1 male at 420 feet, and the remainder from depths of 110 to 213 feet. This shrimp is brown and tan, with a few flecks of chalky white, green, and dull yellow. The orange eggs are about 3.5 mm. in diameter. This shrimp serves as host for a small leech (see "Hirudinea"), and other animals, such as encrusting bryozoans and barnacles, grow on its exoskeleton. Even a small specimen of the clam *Hiatella arctica* was found under one of the dorsal spines. The very large size of the egg of *S. boreas* suggests that in this shrimp metamorphosis takes place inside the egg. In *S. ferox* (Sars), which has an egg 3.5 mm. in diameter, development is direct and the young have the adult form when they hatch (Koelbel, 1881; Wollebaek, 1906). The unusually strong fourth and fifth pairs of pereiopods terminate in a sickle-like claw and for a while these young cling to the abdominal appendages of the mother. If, as seems probable, a similar phenomenon occurs in *S. boreas,* it would account for the transfer of the leech *Crangonobdella murmanica* from the adult to the young shrimps, for the leech hatches from its egg capsule as a young worm. The discovery of this shrimp at Point Barrow extends its range a few degrees both northward and eastward. The Point Barrow specimens (up to 124 mm.) exceeded the Icelandic specimens (up to 100 mm.) in length (Stephensen, 1939).

In view of the number of species in most groups, the small number of species of crabs and hermit crabs was somewhat surprising. Only two hermit crabs and three true crabs were taken—and one of the true crabs was only a sporadic visitor.

Apparently preferring a muddy bottom, *Pargurus splendescens*

(Owens) occurred at Eluitkak Pass and at depths of from 10 to 150 feet. The legs and thorax of this species are large in comparison with the abdomen. This hermit apparently prefers shells of *Natica* and *Polinices* for its short abdomen, or perhaps these shells were the most abundant form in the size appropriate for the small abdomen. The hermit never "wore" a shell large enough to withdraw into, and the large thorax and legs were always exposed. Unlike most of its relatives, it was usually not difficult to remove it from its shell, and it did not evidence the usual distress shown by hermit crabs without a shell. Specimens of this hermit were frequently brought up without any shells at all, but the shells were no doubt lost during dredging. Since plenty of empty shells of *Natica* and *Polinices* were available, the fact that large hermits of this species often wore shells so tiny that only the very tips of their abdomens were inserted in the shells is sufficient evidence of their lack of concern about having their abdomens housed. The carapace and legs of this species were a reddish, iridescent blue. The eggs were dark blue, but they turned to orange in preservative.

Pagurus trigonocheirus (Stimpson) was much more abundant in hauls than *splendescens.* It occurred at Eluitkak Pass and from 110 to 522 feet. Although a few were taken on muddy bottom at 80 feet, this hermit appears to prefer stony substrate or transitional areas between the muddy and stony bottom. Again, this may be more a matter of living where suitable housing is available rather than a preference as to bottom, for the shells of *Neptunea* and *Buccinum,* which this hermit inhabited, were found largely on stony bottom. In contrast with *splendescens, trigonocheirus* often uses shells that are much larger than necessary. Time and materials did not permit the preservation of more than a few of the specimens brought up in hauls. *P. trigonocheirus* is host to two parasitic cirripeds at Point Barrow: *Clistosaccus paguri* and *Peltogaster depressus* (see "Cirripedia"). Two large males had specimens of *Spirorbis* on their telsons and uropods, and a large female had a small colony of the octocoral *Eunephthya rubiformis* growing on its carapace.

The most abundant of the true crabs was *Hyas coarctatus alutaceus* Brandt, which was present in nearly every haul from 80 to 477 feet. Males (carapaces up to 75 mm. long) were larger than the females (carapaces up to 49 mm.). Ovigerous females with freshly deposited eggs were taken from the first of August to the middle of October. This species has a purplish-red carapace, and the legs are reddish brown above and light beneath. The lower two-thirds of the outer face of the hand is white and the lower half of the inner face is white with reddish-brown specks.

On August 12, 1948, a female king crab *Paralithodes camtschatica* (Tilesius), with a carapace 100 mm. long and the longest leg 185 mm. in length, was picked up near shore at Point Barrow base. Men working along the shore about half a mile from the base reported seeing a few others during the morning but an immediate search as soon as the information reached the laboratory failed to yield any other specimens. The crabs apparently had moved on. This female, which still had empty egg cases clinging to her pleopods, was cream with markings of brownish red. On September 4, 1948, an ovigerous female of this species was picked up near shore at the native village—and, needless to say, was summarily eaten. Although the beach at the base was patrolled more frequently in the summer of 1949 than in 1948, no more specimens were seen.

Chionocetes opilio (O. Fabricius) was taken at five stations from 30 to 110 feet and one male was taken at 438 feet. Those from the 30-foot depth were a muddy brown but those from deeper water were a reddish brown, the pigment extending onto the upper surface of the legs. The dactyls and the entire lower surface were white. No ovigerous females were found. With the exception of the one from 438 feet, all the specimens were taken in 1948, suggesting that they stay closer to the shore when ice floes are present than when the ice is completely absent.

Class ARACHNOIDEA

Order PYCNOGONIDA

About 10 species of pycnogonids, 6 of which have been identified, were collected. For these names the writer is indebted to Dr. Joel Hedgpeth, who is still working on about 30 lots belonging mostly to the genus *Achelia,* a difficult genus with more than its quota of taxonomic problems.

Nymphon brevirostre Hodge was taken at 150, 80, 125, and 110 feet (September 16, 1948). One of the specimens from 125 feet was a male bearing eggs. Known largely from the Arctic north of Norway and Russia and with a record from Kamchatka, this species is new to the western Arctic.

Nymphon grossipes (Fabricius) was the most abundant of the three species of *Nymphon.* An ovigerous male was taken at 125 feet and one at 120 feet (August 8, 1949), one specimen at 420 feet and one at 217 feet, and an adult and two immature specimens at 175 feet. The following were found on the beach in 1949: 2 on July 23; 28 (1 immature) between September 9 and 12; 9 (including 2 ovigerous

males on September 26); and 2 (1 ovigerous male) on October 2. It is a circumpolar species, and this is the second record from Point Barrow and the western Arctic, Cole having reported it in 1921.

Fourteen specimens of *Nymphon longitarse* Kröyer were picked up on the beach between July 23 and October 2, 1949. One ovigerous male with four bright tan egg sacs 2 mm. in diameter was taken on September 12, 1949, and another on September 26. This is the second record from Point Barrow and the western Arctic, Cole having reported this species in 1921.

One specimen of *Phoxichilidium quadridentatum* Hilton was found among a mass of hydroids and bryozoans at Eluitkak Pass on August 10, 1948. The only other records of this pycnogonid are from San Francisco, Stewart Island, and one from Point Barrow.

Nineteen specimens of *Pseudopallene circularis* (Goodsir), 12 of which were juveniles, were dredged as follows: 1 male at 80 feet, 2 at 125 feet, and 2 at 110 feet (September 15, 1948); 1 juvenile at 110 feet (September 16, 1948), 3 at 420 feet, 1 at 184 feet, and 2 at 217 feet; 1 male at 341 feet, 1 male and 4 juveniles at 453 feet, and 1 juvenile at 175 feet. The male taken on September 9, 1948, was carrying young just ready to escape. (Stephensen, 1943a, reports an ovigerous male from east Greenland on August 11, 1932.) This is an Atlantic-Arctic-Pacific species.

Tanystylum anthomasthi Hedgpeth was dredged as follows: 1 female at 150 feet and 1 at 125 feet, and 1 male at 217 feet. This species has been reported previously from Hokkaido, Japan, and from Point Barrow.

Phylum MOLLUSCA

At least 128 species of mollusks, plus about 8 varieties, were collected. The approximate number in each group is as follows:

Pelecypods	30 plus 4 varieties
Gastropods	89
Pteropods	2
Opisthobranchs	12
Prosobranchs	70 plus several varieties
Amphineurans	2
Cephalopods	3

There is so much variation in the Arctic mollusks that identification is often rendered extremely difficult. The complete synonymy for some species would cover several pages. An example of the difficulties encountered because of such great variation is given by Thor-

son (1944). He lists four varieties of one species, in addition to the typical form, and refers to intergradations between two of the varieties.

The bivalves include one new genus and species and several species that have as yet eluded identification. The prosobranchs include about 15 species that are either new or of questionable identity. I am indebted to my wife, Nettie MacGinitie, for identifying these groups and also the amphineurans. The results of her study will be published shortly. The opisthobranchs were sent to Dr. F. M. MacFarland, who died before the identifications could be made. They are now going to Dr. H. Lemche of Copenhagen. Dr. Grace E. Pickford identified the octopuses, and Gilbert L. Voss the single species of squid. Dr. Gunnar Thorson of Copenhagen is working on the egg capsules and larvae.

Class PELECYPODA

None of the bivalves was taken in sufficient numbers to be of economic importance, but bivalves do serve as food for other animals. *Serripes groenlandicus* and *Pecten islandicus* are large enough for food but they never appeared in sufficient quantity to make their collection feasible. *Macoma calcarea* is abundant, but it lives in such tenaciously sticky mud that dredging it is not practicable.

Nucula tenuis Montagu lives in muddy bottom and was common at depths of 72 to 122 feet, occurring occasionally in hauls down to 741 feet. A single specimen of *Nuculana arctica* (Gray) was taken at 28 feet, and one or two *Nuculana minuta* occurred in practically every haul from 70 to 741 feet.

Of the three species of *Yoldia* found at Point Barrow, *Yoldia myalis* Couthouy was the most abundant, occurring especially in hauls from 70 to 213 feet, but one specimen was taken at 246 feet, one at 295 feet, and one at 453 feet. About 18 specimens of *Yoldia hyperborea* Lovén were dredged from 72 to 477 feet. Shells of this species from 28 to 32 mm. long are from 2.5 to 3 years old. One shell of *Yoldia scissurata* Dall was dredged at 141 feet.

Pecten islandicus Müller usually came up singly in dredge hauls. Six adult specimens were taken from 175, 341, 420, 438, and 522 feet. Juveniles were also rare. The smallest living specimen, which was 13 mm. high, was found among foliaceous bryozoans.

Although *Mytilis edulis* Linnaeus is the commonest Icelandic bivalve (Madsen, 1949), only a single valve of this species was dredged at Point Barrow(Eluitkak Pass), undoubtedly because there is no place in the immediate vicinity where conditions are suitable for such tidal-zone animals as *Mytilus*.

Musculus discors var. *laevigatus* Gray and *M. corrugatus* (Gray) were common in hauls from 130 to 741 feet. Specimens of *laevigatus* under 20 mm. in length were found nestled in the interstices between barnacles and in old holdfasts of tunicates. Specimens exceeding 20 mm. in length were nearly always covered with a byssal net, although no eggs were found within the net. On the other hand, a specimen of *corrugatus* 12.7 mm. in length that was taken from 184 feet was surrounded by a byssal net that enclosed a large number of embryonic clams still within the egg membrane but with definite valves developed. Eight of the embryonic clams averaged 428.5 microns in length. *Musculus niger* (Gray) was less abundant than the above species. Only two specimens over 30 mm. in length were taken (one of these at 741 feet, the other washed ashore). The other specimens did not exceed 15 mm. in length.

About 16 specimens of *Astarte borealis* Schumann were dredged at depths of 80 to 438 feet, and others were taken from Eluitkak Pass. Old shells from Eluitkak Pass were filled with silt and so tightly closed that they were difficult to open. Since living shells as well as old ones are often badly eroded at the umbos, it was often impossible to distinguish between live and dead specimens without opening the shells. *A. montagui* Dillwyn compares favorably in abundance with *Hiatella arctica* and *Macoma calcarea*. It was dredged from 80 to 453 feet, being especially abundant at 216 and 453 feet. There is great variation in proportions and color in this species, with the result that it has been described many times. Even living shells are often encrusted with colonies of bryozoans or with small barnacles. A specimen 18 mm. long appears to be between 2 and 3 years old, and a specimen 25 mm. long is about 5 years old. This species, probably because of its accessibility, forms a favorite food of *Natica* and *Polinices*.

One to three specimens of *Cardita crassidens* (Broderip) were taken in nearly every haul from 80 to 453 feet. A *Cardita* 24 mm. long and 22 mm. high was 4 years old, and another 24 mm. long and 20 mm. high was 5 years old.

Four specimens of *Clinocardium ciliatum* (Fabricius), from 45 to 62 mm. in length were taken from 110, 152, 453, and 522 feet.

About 30 living *Serripes groenlandicus* (Bruguière) were dredged from depths of 80 to 420 feet, with no more than three in any one haul. The shell of this species is very brittle and often cracks when it becomes dry. In *Serripes* from Point Barrow the lines indicating a cessation of growth while the animal is producing eggs or sperm are about as marked as the annual lines of growth, making the determina-

tion of age difficult. A shell 36 mm. long shows an age of 2 or 3 years and three shells 47, 53, and 54 mm. each show an age of 6 years.

About 16 living *Liocyma fluctuosa* (Dall) were taken at depths of 152 to 741 feet. This clam forms part of the food of *Natica* and *Polinices* and drilled shells are not uncommon.

With the exception of *Hiatella,* probably the most abundant species of bivalve at Point Barrow is *Macoma calcarea* (Gmelin), which was taken from depths of 60 to 741 feet. The greatest number came from 72 feet, where the bottom is a stiff mud of great tenacity. The shells of this species exhibit great variation in the proportion of length to height, degree of inflation, and degree of roundness of the posterior end. Small specimens are higher in proportion to the length than older shells, and it is probable that young *calcarea* have been confused with adult *balthica.* Lines of growth are less distinct than in some species, but a shell 18 mm. long was obviously about 2.5 years old and one 39 mm. long was 5 years old.

A few specimens of *Macoma oneilli* Dall and *M. moesta* Deshayes were taken, the former from 80 to 148 feet, the latter from 50 and 80 feet.

A few living specimens of *Mya japonica* Jay and *M. truncata* Linnaeus were taken, the former mainly at Eluitkak Pass and at 10 feet along the shore, the latter from Eluitkak Pass and from depths of 122 to 477 feet. None of these specimens was large. The largest collected were those that washed ashore. Individuals of *truncata* with shells from 37.5 to 41 mm. long appear to be between 4 and 5 years old.

Three left valves of *Panomya arctica* Lamarck were dredged on August 17, 1949, at 522 feet and one shell of *Panomya ampla* Dall was taken at Eluitkak Pass.

The most abundant bivalve at Point Barrow is *Hiatella arctica* (Linnaeus) (=*Saxicava arctica*). It appeared in hauls from any bottom on which there was some object to which it could attach or some place in which it could nestle, therefore from 110 to 741 feet, and it was especially abundant at Eluitkak Pass. Even hauls along shore in the gravel zone yielded their quota, for in this region *Hiatella* attached to several pieces of gravel by means of byssus threads. This bivalve was found between barnacles, clinging to bryozoans, and among old holdfasts. An old shell of *Astarte borealis* contained 21 living *Hiatella* from 7 to 13.5 mm. in length. A haul from Eluitkak Pass on August 6, 1948, and one from 120 feet on September 15, 1948, contained many hiatellas 2.5 mm. and more long. About half of the mass brought up on August 23, 1948, from 150 feet consisted of old dead shells of *Hiatella.*

Class GASTROPODA

The Point Barrow gastropods present a great deal of data on problems of Arctic distribution, reproduction, and feeding. Variation within a species is often great. The majority of the species lay egg capsules containing large-yolked eggs or nurse eggs or some form of nutriment that permits the development of large nonpelagic larvae or larvae with a short pelagic life; a few retain their eggs until the larvae are in the crawling stage. Because of the rapid filling of the ocean bottom by erosion from shore, empty shells dredged at Point Barrow are never very old.

Order PTEROPODA

Although *Spiratella helicina* (Phipps) was reported to be abundant during the summer of 1947, only two specimens were collected during August 1948, and none was seen in 1949 and 1950.

Clione limacina Phipps was exceedingly abundant at times during the summer of 1948—on August 12, for example—and was common in 1949 and 1950. Larval forms were present in the plankton throughout the winter of 1949. Both larval and adult forms were plentiful alongshore on July 20, 1950. This species forms an important food for whales.

Order OPISTHOBRANCHIATA

A single specimen of *Retusa nitidula* (Lovén) was taken at 477 feet. One *Cylichna occulta* Mighels was taken through the ice on January 25, 1950, and another near shore on July 13 of that year. Two specimens of *Diaphana minuta* Brown were collected, one at 741 feet, the other at 295 feet.

What is believed to be *Aldisa zetlandica* (Alder and Hancock) was taken in the gravel zone in from 10 to 15 feet of water, one on July 20 and two on September 8, 1948. Three others washed ashore on October 16, 1949. This species seems to prefer the occasional patches of sand that have been segregated from the gravel. It ingests detritus containing considerable sand.

Eighteen specimens of what is believed to be *Dendronotus frondosus* (Ascanius) were washed ashore and three were dredged (140 and 150 feet). A translucent white species of *Dendronotus,* with the tips of the cerata chalk white, was infrequently washed ashore and two were dredged at 150 feet.

Four specimens of what may be *Coryphella salmonacea* (Couthouy) washed ashore on September 6 and October 16, 1949.

Several other nudibranchs and tectibranchs were collected but they were not even tentatively identified.

Subclass Prosobranchiata

Admete couthouyi (Jay) was found sparingly. Two young specimens from 453 feet are typical *couthouyi,* but others are quite variable. *A. middendorffiana* Dall was taken infrequently: at Eluitkak Pass, through the ice at 162 feet, and at other depths to 741 feet. A single specimen of *Admete regina* Dall was taken at 522 feet. Two types of egg capsules of *Admete* were collected.

Five living *Ptychatractus occidentalis* Stearns were taken from 341, 438, and 453 feet.

Two living *Pyrulofusus deformis* (Reeve) were dredged, one 142 mm. long, on September 15, 1948, at 130 feet; the other 35.9 mm. long, on August 17, 1949, at 438 feet.

Eleven specimens of *Volutopsius behringi kobelti* Dall were taken at Eluitkak Pass and from depths of 80 to 522 feet, seldom more than one per haul, although three were taken at 216 feet and two at 184 feet. Although Point Barrow is the type locality of *Volutopsius stefanssoni* Dall, only two empty shells were found. An empty egg capsule of the helmet-shaped *Volutopsius* type and of a size worthy of *stefanssoni* washed ashore on October 21, 1949.

Five living specimens of *Beringius stimpsoni* (Gould) were dredged at depths of from 125 to 522 feet. Egg capsules of a species of *Beringius* containing from one to three large embryos with their shells consisting of several whorls were taken shortly after the ice went out, and freshly deposited capsules were taken in the middle of October. This variation in age of embryos at the beginning and end of the open season suggests the possibility of two species or of two age groups of adults or, more likely, that the embryos spend the entire winter developing and are then ready to emerge as young snails as soon as the ice goes out.

Two specimens of *Plicifusus kroyeri* (Möller) were dredged in the rubble zone. Some egg capsules possibly of this species contained recently deposited eggs on October 14, 1949, and others contained from 5 to 9 young snails 3 mm. in length. *Plicifusus verkruzeni* Kobelt and *Colus spitzbergensis* Reeve were taken sparingly from depths from 125 to 522 feet.

Two unnamed species of *Neptunea* and *Neptunea ventricosa* (Gmelin) were taken sparingly in the rubble zone. Old shells were usually inhabited by hermit crabs. These shells, even those occupied

by living snails, are often overgrown with bryozoan colonies and barnacles.

The genus *Buccinum* is well represented at Point Barrow, both as to number of species and number of individuals. Individuals within a species vary tremendously, making identifications exceedingly difficult. It is of interest to note that although there are 14 species of *Buccinum* in Greenland waters and at least 9 or 10 species at Point Barrow, only 3 species, *B. glaciale, B. tenue,* and *B. ciliatum,* are common to both places.

Both large and small masses of egg capsules of *Buccinum* were dredged and were picked up on shore. Time did not permit attempting to ascribe these masses to their respective species.

The most abundant species of *Buccinum* at Point Barrow were *B. plectrum, B. glaciale, B. tenue,* and *B. angulosum* in its several varieties. The first three species came largely from the rubble zone down to 522 feet, with two *tenue* from baited traps at 64 and 80 feet, and one *plectrum* from a baited trap at 64 feet (See "Trapping Through the Ice"). *B. angulosum* was obtained chiefly by means of traps through the ice. The majority of the *B. polare* collected were also obtained by means of traps. Two live specimens of *B. fringillum* Dall, formerly known only from 54 feet from Nunivak Island, were dredged at 453 feet.

A number of specimens of *Boreotrophon* that could be ascribed to *clathratus* (Linnaeus), not hitherto reported from the Pacific side of the Arctic, were taken from 125 to 341 feet. Several other species were common in hauls from 80 to 741 feet. Two egg capsules of *Boreotrophon,* containing two embryos each, were taken on August 30, 1948.

Three species of *Trichotropis*—*T. bicarinata* (Sowerby), *T. borealis,* and *T. kroyeri* Philippi—were taken sparingly in the rubble zone. A group of three egg capsules, possibly of *T. bicarinata,* with 13, 14, and 24 embryo snails, respectively, were taken on September 1, 1949, at 328 feet.

Three specimens of the rare *Aquilonaria turneri* Dall (only six other specimens known) were taken at 477, 453, and 151 feet.

Piliscus commodus (Middendorff) was fairly common from 120 to 543 feet, 39 coming from a haul on October 14, 1949, at 175 feet. *Crepidula grandis* Middendorff was also found from 120 to 453 feet, but sparingly, and the specimens did not live up to their name, for the largest shell was only 32 mm. in length.

Natica clausa Broderip and Sowerby is one of the more abundant gastropods at Point Barrow. Nearly 100 specimens, including about

30 percent empty shells, were taken from Eluitkak Pass and at depths of 100 to 741 feet. The sand-encrusted egg rings of this species appeared in the first dredge hauls of the open season and one that was taken on October 11, 1949, at 453 feet had one young snail in each egg space.

A few specimens of *Polinices pallidus* Broderip and *P. monteronus* Dall were taken at depths ranging from 120 to 741 feet. Egg collars of *Polinices* were dredged and others were washed ashore. A few small ones could be attributed to the above species, but the majority were so large that it did not seem possible they could belong to *monteronus* or to *pallidus* of the size that was collected. Another species may live farther from shore or larger *pallidus* may occur in deeper water or at some place outside the dredging area of this project.

One species of *Onchidiopsis,* possibly *glacialis* M. Sars, and three species of *Velutina* were taken in the rubble zone, mostly in the 400-foot range. Another *Velutina* was collected near shore and from the beach.

Lepeta caeca Müller occurred on rocks from depths of 125 to 477 feet, the majority being found at 217 feet or deeper. The body of the animal is white.

A few specimens of the tiny liotiid *Mölleria costulata* (Möller) came from 453, 477, and 741 feet.

The trochids were well represented by *Solariella obscura* (Couthouy) and *Margaritopsis grosvenori* (Dall) from the rubble zone, mostly from depths up to 216 feet; *Margarites vahli* (Möller) from 120 to 741 feet; *Margarites pribiloffensis* Dall from 477 and 741 feet; and two specimens of *Margarites vorticiferus ecarinatus* Dall from 217 and 341 feet. But much larger and more abundant than all the other trochids together was *Margarites costalis* var. *grandis* that occurred in hauls from 110 to 741 feet, the highest yields coming from 341, 453, and 420 feet. Several of these species are new to Point Barrow. On the basis of abundance of snails and corresponding abundance of egg masses, it seems possible that the egg masses so commonly found on the washerlike bryozoan *Alcyonidium disciforme* may belong to this abundant species of *Margarites.* In describing the egg masses of *M. cinereus* from east Greenland, Thorson (1935a) states that they "are laid on *Laminaria* leaves or other algae as flat, slimy plates." The egg masses on *Alcyonidium* might better be described as firm, jellylike masses. In the absence of algae at Point Barrow it would not be strange if *Margarites* chose to deposit eggs on the abundant *Alcyonidium.*

A single specimen of *Puncturella noachina* (Linnaeus) from 184 feet extends the range of the species to the Pacific side of the world.

Over 10 species belonging to the "Oenopota complex" were collected. The species *nazanensis, harpa, impressa, laevigata,* and *tenuilirata* came from the rubble zone and down to 477 feet. Several of these species are new to Arctic Alaska and some to the Pacific side of the Arctic. Several species have not been identified. Egg capsules of at least two species of *Oenopota* were taken in September and October. The capsules contained embryo snails with shells.

Class AMPHINEURA

Although only two species of chitons were collected off Point Barrow, both species were often present in hauls from suitable bottom. Both are new to Point Barrow, but have been known from the Atlantic, the Atlantic-Arctic, and the Pacific.

Symmetrogephyrus vestitus Broderip and Sowerby, represented by 42 specimens, came from depths of 138 to 741 feet. Although all but the very tips of the valves are covered by the girdle, young barnacles attach to these tips and foraminifers nestle in the depressions formed at the junction of plates and girdle.

The smaller *Trachydermon albus* (Linnaeus), the valves of which are white on the inside but more often brown on the outside, appeared in hauls from 120 to 522 feet.

Class CEPHALOPODA

Two species of octopuses and one species of squid were collected.

On October 6, 1949, a single specimen of *Benthoctopus hokkaidensis* (Berry), a gravid female, was taken at 216 feet. The body, light orange on a cream background, was 57 mm. in diameter and 85 mm. long and the arms were 150 mm. long. This species was taken off Japan by the *Albatross* and more recently by the Russians in the Okhotsk Sea and Bering Sea. The specimen from Point Barrow extends the range into the Arctic.

On September 27, 1948, a juvenile and an adult of a species of *Cirroteuthis* were taken with a dip net from the outer edge of an ice cake that had stranded alongshore. These peculiar animals, which resemble in shape a rag doll more than an octopus, were in about 6 feet of water, where they had obviously been carried by an upwelling of deep water resulting from 3 days of offshore wind. Unfortunately, the larger specimen was lost in transit and Dr. Pickford was unable to identify the species from the juvenile. The larger specimen, mostly

pale maroon in color, had an over-all length of 25.7 cm. Other measurements were as follows: eye to end of body, 14.8 cm.; across open end of "skirt," 13.5 cm.; width at base of fin (posterior), 6.8 cm.; width of fin, 5.8 cm.; length of fin, 6.6 cm.; diameter of siphon, 5 mm.; diameter of eye, 9 mm.; diameter of pupil, 4 mm.

Three specimens of the squid *Gonatus fabricii* (Lichtenstein) washed ashore at Point Barrow on October 1, 1949. They were spotted with red on a cream background. Measurements (in mm.) of these three specimens taken after preservation are given below. The over-all length is to the end of the short tentacles.

Specimen	Over-all length	Length of body	Length of short tentacle	Length of long tentacle	Fin spread
1	110	72	36	42	37
2	92	63	27	41	38
3	86	59	26	37	33

Phylum ENTEROPNEUSTA

Four individuals of an unidentified balanoglossid, the largest measuring 35 mm. in length and 4 mm. in diameter, were taken: three at 125 feet and one at 110 feet (September 15, 1948).

Phylum TUNICATA

Class ASCIDIACEA

Order APLOUSOBRANCHIATA

Approximately 30 species of tunicates, only about one-fifth of which were compound forms, were collected. Not all the species have been identified. Because of the abundance of certain forms only a small portion of those collected could be preserved; many were examined and when the data were recorded the animals were discarded. The writer is indebted to Dr. Donald P. Abbott for identifying a representative lot of tunicates so that field and laboratory notes could be made. Dr. Abbott will complete the identifications and publish his results later.

Several colonies of *Amaroucium fragile* Redikorzev were dredged at 125 feet, and two species of *Amaroucium*, probably new, were found attached to hydroids and bryozoans at 125 and 140 feet. Several colonies of *Aplidiopsis pannosum* (Ritter), completely covered with sand grains, pebbles, and stolons and stems of hydroids, were taken at 125, 130, and 110 feet. This species is new to the Arctic.

The most abundant compound species was *Didemnum albidum* (Verrill), a soft, white encrusting form with stellate spicules in the

test, making the surface gritty. It occurred in every haul from 110 to 741 feet (where it was growing on the tubes of *Pista maculata*). It grew on bryozoans, on barnacles, on stones, and on the holdfasts and stems of hydroids and bryozoans. It is new to Arctic Alaska.

Three specimens of *Ascidia callosa* Stimpson were collected from stones and bryozoans at 125 feet. Cream-colored organs showed through the transparent or translucent tan tunics. It is new to Arctic Alaska.

Chelyosoma macleayanum Broderip and Sowerby was common in hauls from 120 to 477 feet, usually attached to rocks but sometimes growing on other tunicates, such as *Styela*. Four individuals taken on October 14, 1949, had immature ovaries but well-developed testes. This species is new to Arctic Alaska.

Order STOLIDOBRANCHIATA

Dendrodoa pulchella (Verrill) was common in all hauls from 110 to 140 feet and also occurred at Eluitkak Pass. It was usually attached to stones but also grew on other tunicates such as *Styela* and *Boltenia echinata*. The tunic varied from flesh color to dirty flesh to muddy tan. It is new to Point Barrow.

Dendrodoa grossularia (van Beneden) was common on rocks from depths of 125 to 216 feet. Most specimens are characterized by a bluish tint around the siphonal openings. An individual taken on October 6, 1949, was filled with eggs 0.25 mm. in diameter. It is new to Arctic Alaska.

One of the commonest of the simple ascidians was *Styela rustica macrenteron* Ritter, which was found at Eluitkak Pass and was abundant in hauls from 120 to 453 feet. Bryozoans, young barnacles, and *Didemnum albidum* were often found growing on its cream-colored tunic. Foraminifers often nestle in the tunic, forming depressions so deep that the testes scarcely project above the surface of the tunic. Although numerous individuals were opened and examined for copepods, none was found. Individuals from 35 to 45 mm. in height that were examined on October 14, 1949, had immature or developing testes and well-developed ovaries. Specimens from 7 to 8 mm. high were found from the first of August to the middle of October. This species is new to Point Barrow.

Styela coriacea (Alder and Hancock), less abundant than the above species, was found at Eluitkak Pass and in all hauls from 110 to 140 feet. It may be present in unidentified material from deeper hauls. It is new to Point Barrow.

With the exception of *Rhizomolgula,* the most abundant simple ascidian was undoubtedly *Boltenia echinata* (Linnaeus) with its cream tunic tinged with red, especially around the apertures. Externally it resembles a cactus. From a few to many individuals were present in all hauls from 110 to 453 feet. One small stone from 217 feet had five *echinata* on it. Usually attached to stones, it may be found also on bryozoans and other animals. Young specimens up to 15 mm. were attached to *Porella compressa.* Numerous individuals were searched for parasitic copepods and a total of 10 specimens of a new species of *Doropygus* were found. *Boltenia echinata* represents a new host for this genus of copepod. In a specimen of *Boltenia* 17 mm. high taken on October 11, 1949, at 453 feet the ovaries and testes were about half developed.

Not far behind the above species in abundance was *Boltenia ovifera* (Linnaeus), also present in all hauls from 110 to 453 feet. Specimens with stalks up to 170 mm. long were taken. *B. ovifera* is found attached to rocks, bryozoans, other tunicates, and to old holdfasts of hydroids and bryozoans. Occasionally large clusters of small to medium individuals with intermingled holdfasts and stalks were brought up. Out of 63 individuals examined on October 14, 1949, 4 contained the parasitic copepod *Schizoproctus inflatus* Aurivillius. Two copepods were taken from 26 tunicates from 453 feet, and one young copepod came from a small tunicate from 341 feet. This species appears to have no definite breeding season. Specimens examined on October 11, 1949, had gonads in various combinations of development, some with full testes and fairly full ovaries, others with empty testes and full ovaries; in others both testes and ovaries were developing, and in still others one testis might be small, the other, half developed, and the ovaries fairly well developed.

The largest and most conspicuous, but far from the most plentiful, tunicate was *Halocynthia aurantium* (Pallas), with its flesh-white tunic with traces of yellow and with a deeper flesh-pink color on one side. From one to several specimens were taken in hauls from 110 to 217 feet. It is new to Point Barrow.

Perhaps often overlooked because of its small size, its transparency, and its habitat, *Molgula griffithsi* (MacLeay) was abundant at Eluitkak Pass and in hauls from 118 to 477 feet. It was commonly attached to the hydroid *Lafoeina maxima* which was also abundant, to other hydroids, and to bryozoans such as *Barentsia, Eucratea,* and *Dendrobeania.* At 477 feet it was attached to the tubes of *Pista.* Small as this species is, one individual had a species of *Tubularia* (hydroid)

growing on it. An individual taken on August 1, 1950, at 118 feet contained pale coral eggs that appeared ripe.

Three specimens of *Molgula retortiformis* Verrill were taken at 120 feet (August 30, 1948), 125 feet, and 140 feet, and possibly a fourth from 741 feet.

Four individuals of a species of *Molgula,* probably new, were taken at 110 feet.

Another pebble-covered new species of *Molgula* was represented by 29 specimens from 110, 125, 130, 184, and 217 feet. Some of those from 184 feet were filled with eggs that had developed sufficiently that the "tapole" larval tail could be seen.

Rhizomolgula globularis (Pallas) is an almost spherical species about the size of a small marble and so sand-encrusted that when it is contracted the siphonal openings are difficult to see. It inhabits a sandy-mud bottom, hence in the vicinity of Point Barrow it is limited to a few spotty areas between the base and the village of Barrow. One such area was found from 75 to 150 feet from shore and another about a mile from shore, both at a depth of from 10 to 15 feet. Thousands of these tunicates live in these localities. One short haul brought up a dredge one-third full of little except these tunicates. The first time the Eskimo boatman saw them, he exclaimed, "Ha, raisins!" In 11 specimens examined on September 8, 1948, both ovaries and testes were developing; in one the testes had spawned out and the ovaries were not quite mature, in two the ovaries were spawned out and the testes were about half developed, and in another both testes and ovaries were small. It is new to Arctic Alaska.

One specimen of *Eugyra glutinans* (Möller), new to Point Barrow, was taken at 125 feet.

Among the unidentified species is a slender, baseball-bat-shaped tunicate that lives with the basal two-thirds embedded in the mud. It was obtained at 10 and 120 feet and on shore after storms. Another species that washed ashore was a stalked form with a clear tunic through which the white testes and orange ovaries were visible. Still another species of *Molgula* contained eggs approximately 0.7 mm. long.

Phylum VERTEBRATA

Class PISCES

Although fishes were not within the scope of this project, any that were found in the course of collecting invertebrates were preserved and turned over to the U. S. National Museum in 1948 and to Nor-

man Wilimovsky in 1949 and 1950. Data furnished by the writer will be incorporated in Mr. Wilimovsky's report.

I had hoped to locate some new source of food for the natives—clams, shrimps, or perhaps some large fish that could be caught by methods other than those employed by the Eskimos. At first it was difficult to accept the statement by Eskimos that no large fish live in the ocean at Point Barrow. (A number of large fishes inhabit the rivers and lakes.) However, if large fish were present in the ocean around Point Barrow, the whalers would have discovered them in the hundred or more years they were whaling in that region even if the Eskimos had not. After dredging and becoming acquainted with the invertebrate fauna, it was realized that certain of the animals could not exist in such large numbers, especially on the smooth mud bottom where there is no refuge of any kind, if large, bottom-feeding fish were present. Admiral Byrd told me that on his expeditions they were never able to catch large food fish within the vicinity of the ice fields of the South Polar regions. Large fish apparently have not been able to adapt themselves to a temperature of $-1.8°$ C.

The most abundant marine fish at Point Barrow, and the most important from an economic standpoint, is the Arctic cod, *Boreogadus saida* (Lepechin). During the summer of 1948 these could be caught at almost any time by going out to a large ice floe and fishing through a crack in the ice. Fishing gear consisted of a wand or stick about 30 inches long, a piece of leader about the same length, and a small hook of some kind. The Eskimos usually use a barbless hook consisting of a small spatulate piece of ivory with a brass tack through the distal end. Almost invariably cracks from 3 to 6 inches wide in a large floe have Arctic cod swimming around in the water in them, and several dozen can be caught within a short time. But these fish form a precarious source of summer food because the possibility of catching them in this manner depends upon the presence of large ice floes. In the summers of 1949 and 1950 very few Arctic cod were caught by the Eskimos, and laboratory personnel could not obtain enough for physiological studies. But they were present in the offshore waters, as was evidenced by the fact that numerous individuals washed ashore during storms. During the winter the Eskimos obtain these fish by jigging for them in about 80 feet of water through a hole in the ice.

Another marine fish used by the natives is the capelin *Mallotus catervarius* (Pennant), a small fish about the size of a smelt that comes to the very edge of the surf to lay its eggs but does not spawn above the water as does the grunion along the coast of California.

The eggs are deposited in the gravel. During spawning these fish can be caught in considerable quantity with hand nets from the shore, and for a period of several weeks they frequent the shore waters in such numbers that a few can be taken by sweeping long-handled nets through the water.

Another marine fish that is eaten occasionally by the natives is a sculpin (*Myxocephalus quadricornis*) that was most frequently taken in nets at Elson Lagoon and occasionally along the ocean shore. During the first part of September gravid females were taken, and it is probable that this fish comes into Elson Lagoon or alongshore to spawn. With its large head and slender tail, the sculpin offers little flesh to reward one's efforts, but the Eskimos do not turn down anything that is edible.

The capelin and the sculpin are only seasonal visitors, or at least can be obtained only seasonally. The Arctic cod is plentiful only during those summers when there are large ice floes alongshore, and in the winter it cannot be obtained in sufficient numbers to constitute a dependable source of food. However, the fishes available from all sources must furnish an important supplementary food and a welcome variety to a limited diet.

All fish are directly or indirectly dependent upon the marine invertebrates for their food.

Class MAMMALIA

The marine mammals of the Point Barrow region are of great importance to the native Eskimos, for their presence or absence often means feast or famine.

A population of 125 to 150 at Barrow Village was supported by hunting; but during the past 25 years or so this has increased to over 1,000, by reason of the additional means of livelihood created by naval and other activities.

A curious fact about the Eskimo birth rate is that it greatly increases when the Eskimos eat "white man's" food. When hunting was the only means of subsistence, Eskimo women became pregnant only once in several years, but with the new diet they bear a baby about every year. The writer's boatman, Max Adams, had five girls, the eldest five years; his brother had four boys and one girl, the eldest five years. One of the laboratory Eskimo employees had ten children, another eight, and a third four, the eldest six years. What is going to happen when outside support is shut off is an important and serious problem. Some few fathers are training their boys in hunting and

older Eskimo skills, but most of them are content to let the future take care of itself.

In contrast to the Indians, who are wards of the Government, the Eskimos are citizens and as such are subject to all laws governing citizenship. However, they are still allowed to hunt and kill game at will. In most places they not only kill to supply their own needs, but for food for their dog teams as well. The situation is fast becoming a problem difficult of solution.

Although the marine invertebrates of the Point Barrow region are not a source of food for the natives, they are nevertheless of great importance for they furnish food for the marine mammals that are eaten by the Eskimos.

The whales (mainly bowhead) are of first importance as a source of food for the Eskimos, several being taken in the spring of each year and the flesh stored underground in cellars, where it remains edible for three or four years. They feed on euphausiids ("krill" of the whalers) mysids, pteropods, and copepods of which there is an unlimited supply. This food is so abundant that the great blue whale can attain a weight of 60 tons in two years. Baleen whales probably lead the easiest life of any mammal. These enormous creatures have only to swim slowly through water which has about the same specific gravity as themselves, opening and closing their mouths and swallowing food.

To an Eskimo the most delectable food is whale muktuk, which consists of whale skin with about an inch of the underlying blubber. After freezing, the muktuk is cut into small squares and eaten raw. It has a nutty flavor and is really quite good.

Perhaps next in importance in the native economy is the bearded seal. This marine mammal, which reaches a weight of 500 to 600 pounds, feeds almost exclusively on amphipods, using its whiskers for sweeping them from the underside of the ice. The teeth are very small and are of little use for holding or masticating food. In winter these seals are hunted in offshore leads; they float when shot, so can be taken easily. In summer they are hunted in boats; they sink when shot, and if not immediately harpooned, are lost. I accompanied my two boatmen on a summer hunt and although 11 seals were shot, 7 were lost.

The little harbor seals are abundant and have habits much the same as those of the bearded seal, but they seldom if ever weigh over 50 pounds.

According to generally reliable information, the walrus is not nearly so abundant as formerly; seldom more than 25 walruses a year are killed at Barrow, and in those summers when the ice goes far offshore

few, if any, walruses are taken. They feed on clams and perhaps to some extent on sausage worms (*Echiurus echiurus alaskanus*).

Of least economic value is the polar bear, for it is not prized as food by the natives. The skin is used, though not to the extent that sealskin is. The polar bear is afraid of nothing, for no animal of the Arctic except man is likely to injure it, and the chance of its encountering man in the vast expanse of ice over which it roams is remote. When a hunter is sighted, the bears will walk right up to him to investigate, and Eskimos often let them come as close as 25 or 30 feet before shooting them. Polar bears feed almost exclusively on the two seals mentioned above. They are usually infested with *Trichinella* worms, but from what source is not definitely known.

Before leaving the subject of marine mammals, mention should be made of the use of their skins, which supply certain special needs of the natives. (Caribou is the most widely used for clothing, and wolverine fur, which is unique in that it does not allow the breath to freeze on it, is often used to border parka hoods.)

Skins of the bearded seal are used for many purposes, especially for making soles for mukluks, covering boat frames, and making thongs to be used as ropes and cords. Skins of the little harbor seal are made into air floats that are attached to harpoon lines for floating whales so they can be located after they have died. Walrus skins are also utilized in various ways.

All these marine mammals, upon which the Eskimos are so dependent for food, clothing, and implements, are in turn dependent, either directly or indirectly (but largely directly), upon the marine invertebrates for food.

DISCUSSION

It is the practice in many ecological investigations to count every animal in every haul and give the total weight of each species. From the results the "dominant" animal is selected and the animals to be found at certain depths are listed. This is very time-consuming, and the results do not justify the amount of time spent.

There are many factors in addition to the type of bottom and the depth that determine the number of animals taken in any one dredge haul. Some, such as certain snails and ophiurans, congregate for mating, and a dredge haul through a congregation of such animals would give an entirely erroneous idea of the "dominant" animal in that locality. Others, such as certain sea urchins, habitually move about over the ocean bottom in colonies, and might be at one place one day and at another several weeks later. Sometimes an animal is vastly de-

creased in numbers by predators. When the food is gone the predators decrease in numbers, and then their prey increases in numbers. The time of dredging in relation to this cycle would affect the number of certain species.

Still other factors have a bearing on the number of species found in any locality. When larvae settle out of the plankton to become bottom dwellers they may scatter, or they may settle in large numbers in a small area. Sometimes the bottom is unsuited for that particular species; or, if the bottom is suitable, conditions existing at the time of settling influence the number that survive. Under favorable conditions a large number of individuals of a species may become established, but if conditions are adverse only a few survive even though a large number of larvae of that particular species are settling to the bottom. For instance, if the bottom is already well populated, fewer larvae can become established than if the bottom were sparsely populated. Also the presence of large numbers of other bottom-dwellers that feed on settling larvae will greatly reduce the species.

The futility of trying to collect weight–numbers data for a locality is well demonstrated by the results of the investigation at Point Barrow. Such data for the entire rubble zone in 1949 would be entirely different for the same area in 1950 after the deposition of mud during the fall of 1949. The animals found at depths of 100 to 200 feet in 1948 and 1949 were not the same as those found at the same depths in 1950. A station that yielded a certain fauna one summer might yield an entirely different fauna a year or two later after it had been gouged out by an ice floe.

An enormous amount of time and dredging is required to acquire weight–numbers data, and it seems much more to the point to learn more about the animals themselves—how and on what they feed, how and when they reproduce, how fast they grow, how long they live. Production of food in the economy of the sea depends on the rate of reproduction and the rate of growth and these characteristics are too often neglected in order to present pretty pictures of animals on the ocean bottom in an attempt to illustrate relative abundance and "dominance."

In certain instances in treating the individual species in the "Discussion of Animals by Phyla," a comparison or contrast is made with the same species from Greenland or Iceland. Detailed comparisons would be a work in itself and is out of the question until identifications are complete, but a few are of interest.

Because of less variation in ecological factors, there is little doubt that the region of Point Barrow supports a fewer number of species

than do such regions as Greenland and Iceland. The waters around Greenland are showing much more effect of the warming of the Arctic that is taking place at present than are the waters around Point Barrow for, as far as could be determined, no changes have taken place in the Chukchi Sea comparable to those around Greenland, where the cod, for instance, has migrated 1,000 miles northward.

In both Greenland and Iceland there are fjords and rocky shores that provide habitats for different types of animals—a condition in contrast to the open water around Point Barrow and entire absence of any shore fauna. The total absence of macroscopic algae (except for about two species in Elson Lagoon) excludes certain animals from the Point Barrow region.

The investigation at Point Barrow extended only a few miles out from the base; whereas the work along east Greenland covered an area from the 60th to beyond the 77th parallel of latitude, including the intensive investigation of many fjords in addition to offshore dredging. The Icelandic investigations covered the entire coast as well as offshore work.

Despite the differences in ecological factors and extent of the investigations, in regard to time, depth, and territory covered, the number of animals found at Point Barrow compares very favorably with those from Greenland and Iceland, as the following table shows.

TABLE 9.—*Comparison of the fauna of Point Barrow, east Greenland, and Iceland*

	Number of species		
Animal Group	Point Barrow	East Greenland	Iceland
Priapulids	2	3	3
Sipunculids	2	6	6
Echiuroids	2	2	2
Brachiopods	2	5	9
Amphipods	100	153	181
Pelecypods	38	?	88
Prosobranchs	70+	84	132

The amphipods from Iceland were collected from the surface down to depths of about 1,250 feet, and a few in deeper water. Most of the dredging at Point Barrow was done at depths of less than 200 feet, only 14 of the 65 stations exceeding 200 feet, and 8 exceeding 300 feet, and the greatest depth being 741 feet.

Table 10 gives the approximate number of species of animals in each group, the number of new species if known, and a general idea of the extension of range of the species. In several of the groups the

animals have not all been identified. For example, few of the coelenterates, about 20 out of approximately 30 species of tunicates, and 14 of an approximate 21 species of copepods have been identified. Literature on extent of the range of some of the animals was not available, so that these data could not be given. For example, out of 21 species of decapods, 1 is new to the Arctic, 2 to the western Arctic, 1 to Arctic Alaska, 4 to Point Barrow, 1 has been reported previously from Point Barrow, and exact data are lacking on 10 species. By "western Arctic" is meant any place west of the American Archipelago along the Canadian or Alaskan coast. "Arctic America" excludes Greenland.

TABLE 10.—*Synopsis of the invertebrates of Point Barrow, Alaska*

Invertebrates	Total No. of species	New to Arctic	New to Arctic America	New to western Arctic	New to Arctic Alaska	New to Alaska	New to Point Barrow	New species
Protozoans			Distribution data lacking					13
Foraminifers	75							
Poriferans	10		Distribution data lacking					3
*Coelenterates								
Hydroids	21 ?		1	1	1		1	
Trachyline medusae	3							
Scyphozoans	3							
Anthozoans	9							
*Ctenophores	3							
Platyhelminthes								
Turbellarians	2			1				1
*Cestodes	2							
*Nematodes	?							1
Nemerteans	24	10					11	0
Sipunculids	2						1	0
Priapulids	2		1			1		0
Echiuroids	2	1	1					0
Chaetognaths	3							0
Brachiopods	2						1	0
Bryozoans	99	8	12	38	6	6	10	13
Entoprocts	2	0	2					0
Annelids								
Polychaetes	88	2	9	10	54		13	1
Hirudinea	1		1					0
*Echinoderms	20			3	5	1		
Arthropods—Crustaceans								
Ostracods	5				1	3		0
*Copepods	17+		3	1	7			2-3
Cirripedes	5						2	0
Mysids	3			1				0

TABLE 10.—*Synopsis of the invertebrates of Point Barrow, Alaska*—continued

Invertebrates	Total No. of species	New to Arctic	New to Arctic America	New to western Arctic	New to Arctic Alaska	New to Alaska	New to Point Barrow	New species
*Cumaceans	9	4			2			3
*Tanaidaceans	1							
*Isopods	11	2		1			1	1
Amphipods	100	3	43	12	3	6	13	8
Euphausiids	3		1	1				0
Decapods	21	1		2	1		4	0
*Arthropods—Pycnogonids	10			1		1		
Mollusks								
*Pelecypods	38	2	2	2	1	1	16	1
*Gastropods	89	12	4	3	10	2	23	4-10
Amphineurans	2						2	0
*Cephalopods	3							1
*Enteropneusts	1							
*Tunicates	30				1		19	?
Totals	721	44	80	77	92	21	117	53-59+

* Indicates that not all the species have been identified.

Even though the data on the ranges are still incomplete, the ranges of 339 animals have been materially extended and new locality records have been established for an additional 90 species. In addition there is a minimum of 52 new species. The large number of animals with extended ranges is not surprising in view of the fact that the total number of invertebrates collected is approximately 722, whereas the International Polar Expedition to Point Barrow collected only 188, including a few fresh-water species.

The distribution of the species according to oceans is set forth for a few groups in the table below:

TABLE 11.—*Number of species common to the Arctic and adjacent oceans*

Invertebrates	No. of species	Arctic, Atlantic, Pacific		Arctic Atlantic		Arctic Pacific		Arctic	
		No.	Percent	No.	Percent	No.	Percent	No.	Percent
Sponges	10	0	0.0	4	40.0	3	30.0	3	30.0
Nemerteans	24	6	25.0	5	20.8	12	50.0	1	4.2
Bryozoans	84	39	46.4	26	31.6	14	16.5	5	5.8
Polychaetes	88	75	85.2	3	3.4	5	5.7	5*	5.7
Amphipods	100	37	37.0	31.0	31.0	7	7.0	25	25.0
Decapods	19	5	26.3	2	10.5	12	63.2	0	0.0
Pelecypods	33	20	60.6	2	6.0	11	33.3	0	0.0
Prosobranchs	70	26	37.1	10	14.3	32	45.7	2	2.8
Totals	428	208	48.6	83	19.3	96	22.4	41	9.6

* Includes two species common to the Arctic and the Antarctic.

The totals in the above table show that 48.6 percent of the animals collected at Point Barrow are common to three oceans and 41.7 percent are common to two—19.3 percent to the Arctic and Atlantic, 22.4 percent to the Arctic and Pacific; while 9.6 percent have been found in the Arctic only (two of the species also found in the Antarctic). These figures bring out some facts that stimulate one's curiosity to say the least. Why have animals that have found their way into one ocean below the Arctic not found their way into the other? From what has been said under "Distribution," there must be factors other than the rate of distribution that account for the range of these animals. Temperature may be one of them but its limited variation in the Arctic-Pacific should make it possible for any animal that lives in the Arctic-Atlantic to extend its range into the Pacific. Perhaps the constant flow of water from the Pacific into the Arctic may be an important factor but if so, any animal found in the Arctic-Pacific should also be found in the Atlantic. Such speculation could go on endlessly, but it is of little value unless followed by the actual testing of theories.

From table 11, some interesting comparisons can be made between the individual groups: 85.0 percent of the annelids are found in both adjacent oceans, while only 60.6 percent of the pelecypods and 37.1 percent of the gastropod prosobranchs are found in both the Atlantic and Pacific. More mollusks are common to the Arctic and Pacific than to the Arctic and Atlantic. (This discrepancy may disappear when the remaining 10 or 15 gastropods, which are either new or else Atlantic forms, are identified, for they certainly are not Pacific forms.) Of the amphipods 31.0 percent are common to the Arctic and Atlantic while only 7.0 percent are common to the Arctic and Pacific, and 25.0 percent are restricted to the Arctic. Two and a half times as many nemerteans are common to the Arctic and Pacific as to the Arctic and Atlantic.

In general, it would seem that there should be more species common to the Arctic and the Atlantic because of the greater variation in ecological factors on the Atlantic side. However, the totals show that 19.3 percent of the species are common to the Arctic and Atlantic as against 22.4 percent common to the Arctic and Pacific.

The large number of annelids that range outside the Arctic is interesting and, because of the thorough study of this group by Dr. Pettibone, the figures must be so accurate that it is safe to assume there will be little change in them as future work goes on. Annelids would seem to be more adaptable to varied conditions than are other marine invertebrates, especially such groups as the brachiopods.

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